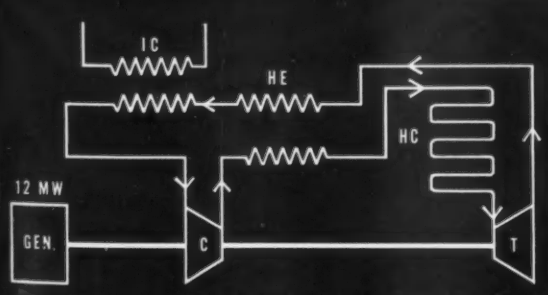
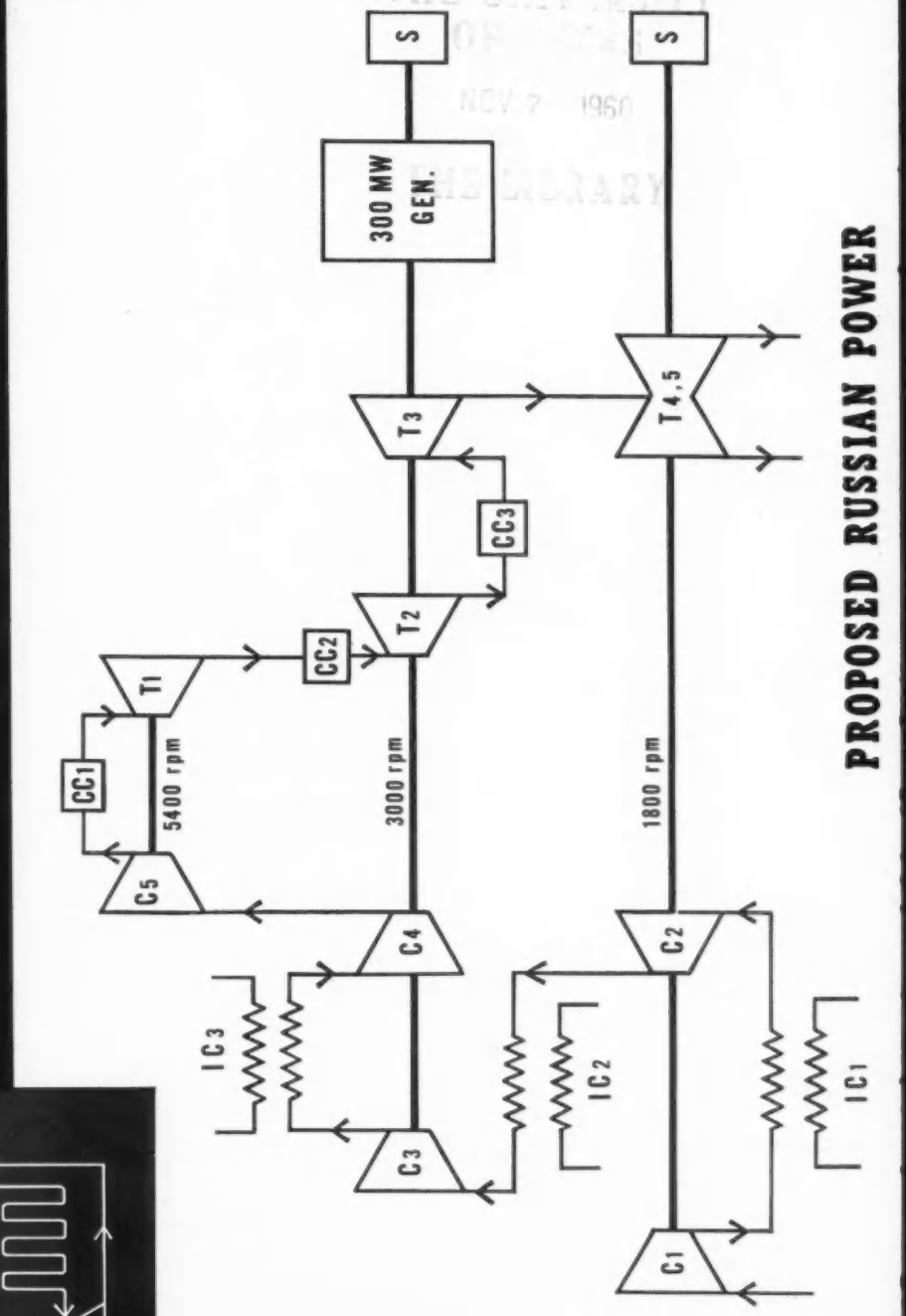
NOVEMBER-DECEMBER 1960

GAS TURBINE

RUSSIAN GAS TURBINES



PRESENT RUSSIAN POWER



PROPOSED RUSSIAN POWER

120 KVA Electrical Power and Pneumatic Starting for Jet Aircraft...

AiResearch GPV-91 gas turbine and 120 KVA alternator ground power unit

This single AiResearch ground power package provides all the electrical and pneumatic power needed to meet the increased ground support requirements of the newest jet transports. At the same time, the new dual-purpose GPV-91 results in a unit that effects considerable dollar savings over separate units to provide pneumatic starting and electrical services.

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The compact power unit consists of an AiResearch GTCP 85-91 gas turbine driving a 120 KVA alternator. This gas turbine features automatic operation and pushbutton starting, operates in any weather extreme from −65° to 130°F. Optional 28 volt dc power is available up to 1600 amperes.

This lightweight power package can be installed on nearly any vehicle or carried as an onboard unit. AiResearch has delivered more than 9000 gas turbines in the 30 to 850 hp range, and is the world leader in producing turbine ground support for airliners.

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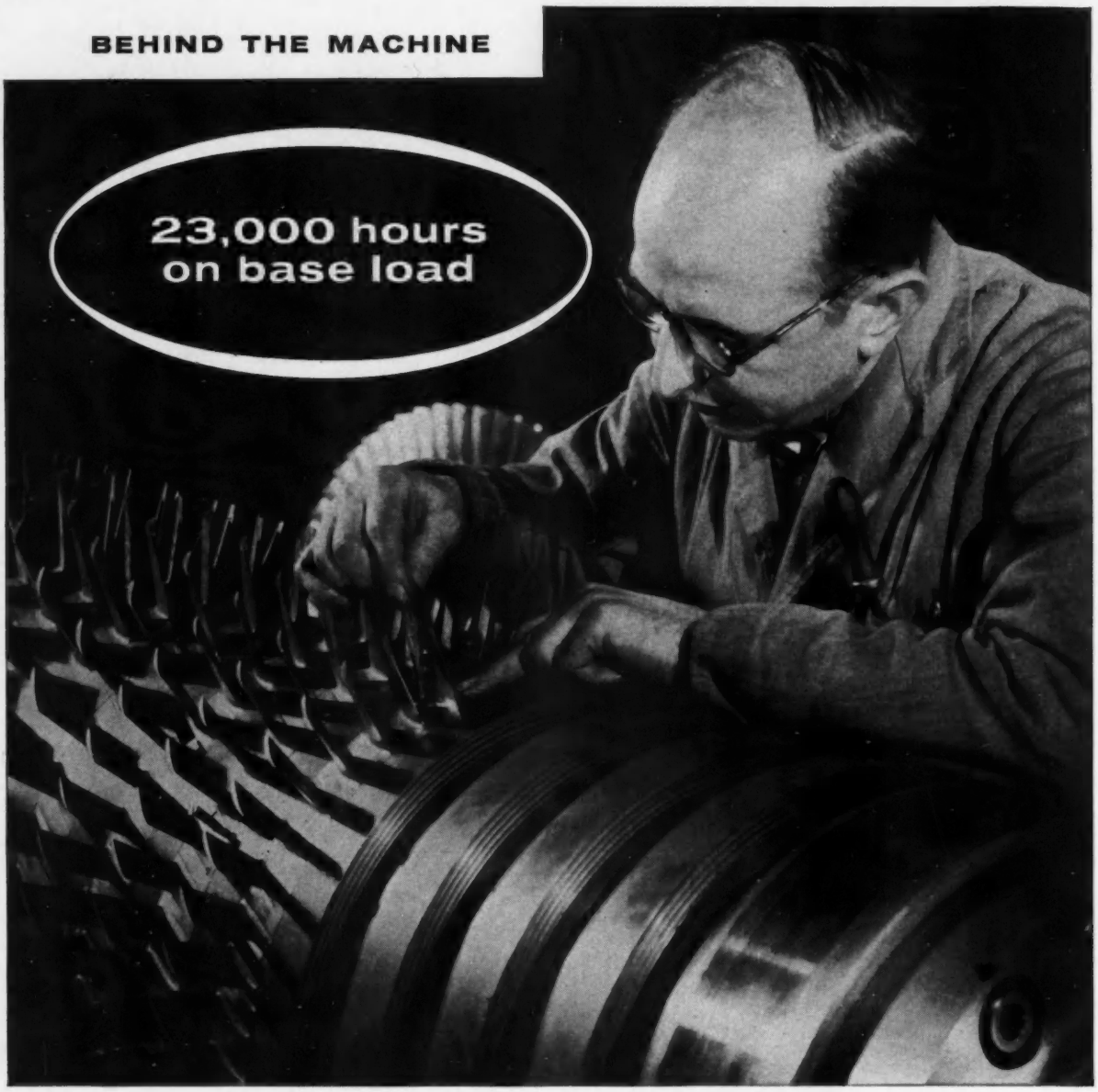
BEHIND THE MACHINE



The proved reliability of AEI industrial gas turbines is typified by a machine in Venezuela which has recently completed 23,000 hours running on base load. AEI makes a range of industrial gas turbines with ratings from 1,750 kW upwards designed to run on gaseous or liquid fuels.

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This is a product of AEI Turbine-Generator Division, Britain's largest manufacturer of Turbine-Generators.

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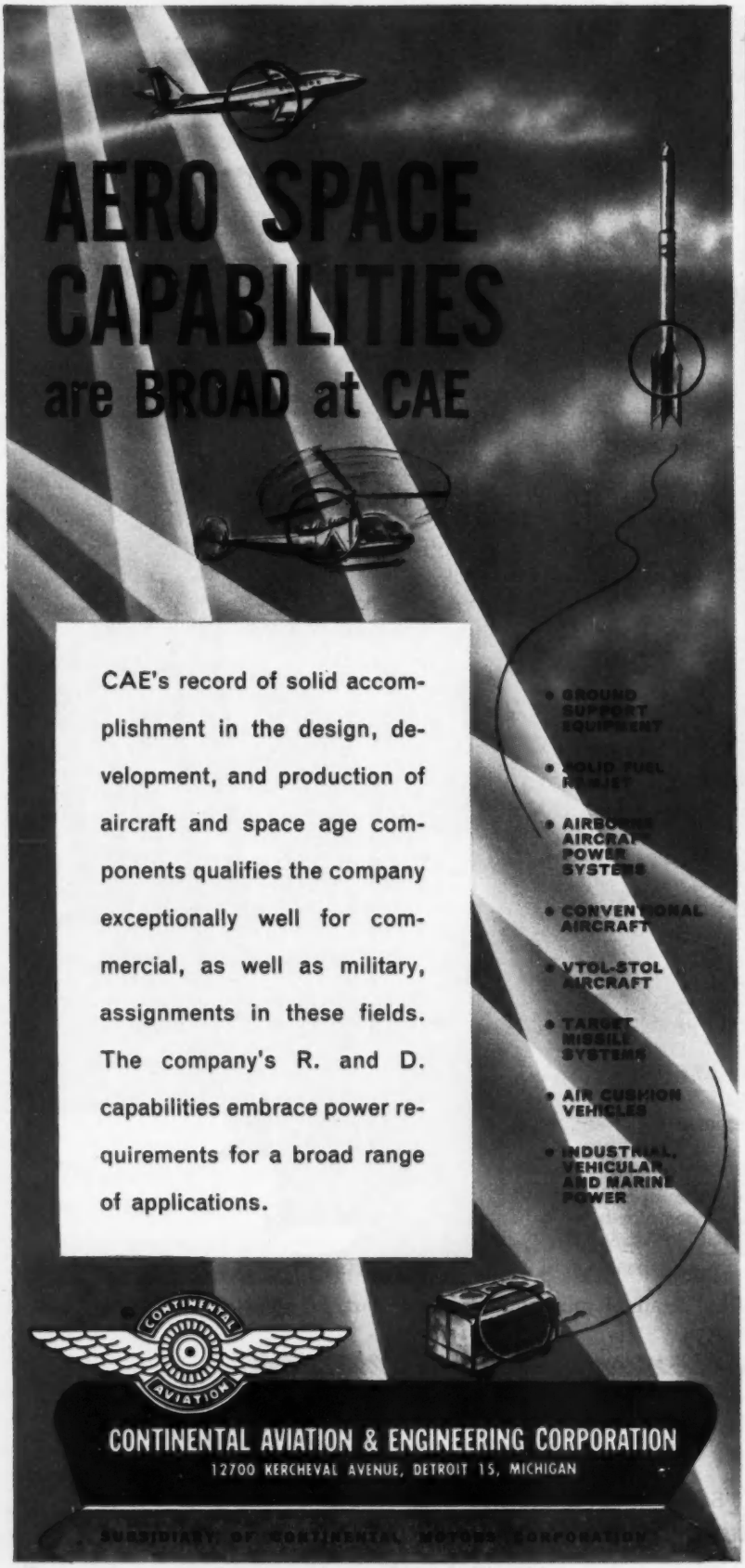
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CONTACT:
J. M. CLARK, Exhibit Manager
Gas Turbine Power Division
793 Delafield Ave.,
Staten Island 10, N. Y.
PHONE: Gibraltar 2-3227

"The Defense Department specifically desires that the exhibits to be shown either at the Pentagon or at the Shoreham, be production units for industry."

For more information write in No. 134

GAS TURBINE

VOLUME 1, No. 6, November-December, 1960

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Back Issues — Twice Published Rate

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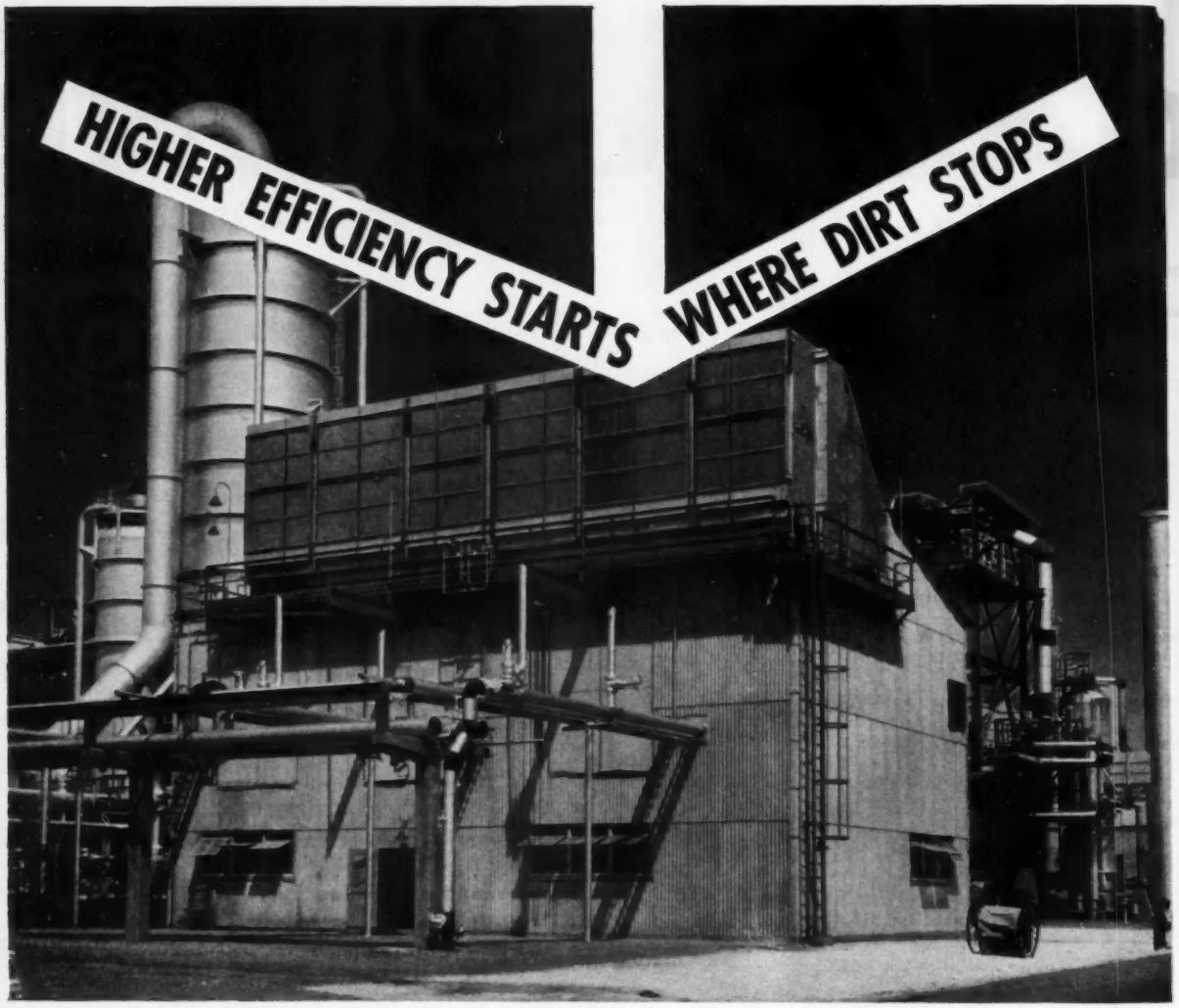

AAF cleans and cools intake air, helps boost petrochemical output

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GT EDITORIALLY SPEAKING

Together They Succeed!

Certain nations have been noted for leading in development of various types of power sources—the Dutch for the wind mill; the English, the steam engine; the Germans, the diesel; the Swiss, the gas turbine; the Americans, nuclear power; and the Russians, rockets from the viewpoint of sheer size. It's interesting that power sources, once developed, never completely disappear from the scene. We find today: Windmills are still used. Steam is still used but engines have been replaced for the most part by turbines. The diesel is world-wide in development and application. In the relatively new gas turbine industry, the English lead in commercial aircraft gas turbines with America a close second. The Swiss and Americans are leaders in the large industrial gas turbine. Today, Americans are leading in small APU gas turbines and the number of highly-efficient small regenerative units under development. Also, Americans are not only the leaders in building auxiliary gas turbines for rocket pumps but lead in the *overall range* of rocket building and vertical lift technology. So . . . . while each single country appears to excell only in a narrow segment of the gas turbine industry, taken together they are expanding the gas turbine industry across a very broad front, even including aero-space developments. Oddly enough, the rocket or space vehicle may be a combined application of all of today's newest prime movers.

Big gas turbine jets clustered around the rocket core can lift it vertically to outer space where the core with its APU is the main engine to send the "pay load" to its destination.

Know-how of prime movers came from many countries, the gas turbine being no exception. At least a dozen of the top nations of the world are each spending millions to develop and produce gas turbine prime movers. **Together They Succeed!**

R. Tom Sawyer

GT HOT LINE

GOVERNMENT INVESTS IN GAS TURBINES—$337-MILLION WORTH!

US Government has spend 1/3 of a billion dollars on gas turbines since 1st of January 1960. See "Company Reported Contracts" in the Industry News section of this issue of GAS TURBINE.

BIG NEW JET ORDER FOR GE . . .

General Electric's large jet Engine Department has received a $58-million plus production contract for its J79-8 engines. Let by the Air Materiel Command's Aeronautical Systems Center at Wright-Patterson Air Force Base, the contract is for engines to be delivered in 1961 and 1962.

PRATT & WHITNEY AIRCRAFT MOVES AHEAD . . .

Pratt & Whitney's complete line of industrial gas turbines for all major applications now includes six basic units, ranging from 350 to 15,000 hp. They may be operated as gas producers . . . or have an integral free power turbine, such as the 10,500-hp unit driving a Cooper-Bessemer power turbine and gas pump now installed at the Columbia Gulf Transmission Company's station in Kentucky.

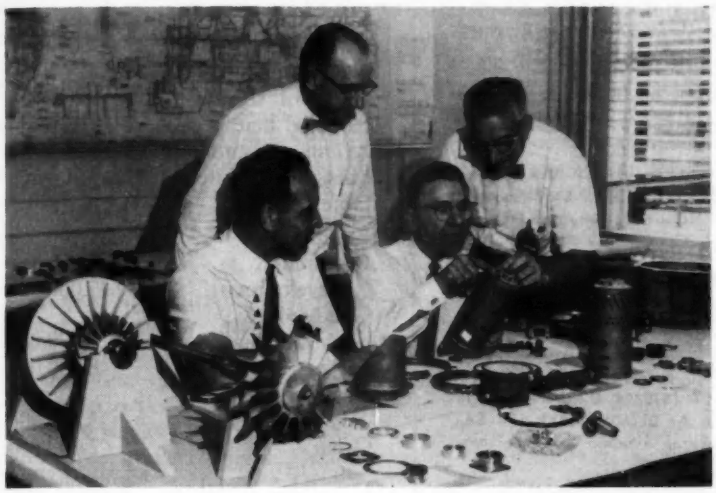
GE'S 20,000-HP TURBINE SLATED FOR SEA DUTY . . .

Grumman Aircraft Engineering Corporation's affiliate, Dynamics Developments, Inc., is at work designing and building world's first open-sea hydrofoil vessel for US Maritime Administration. This 90-ton, 104-ft, sea-going testbed is expected to achieve speeds of approximately 60 to 80 knots. It'll be powered by General Electric's 20,000-hp gas turbine, the 240. GE's 240 is a jet unit rebuilt at their Evendale plant with a power turbine designed to drive the propeller shaft.

WILLIAMS WORKING WITH WAUKESHA . . .

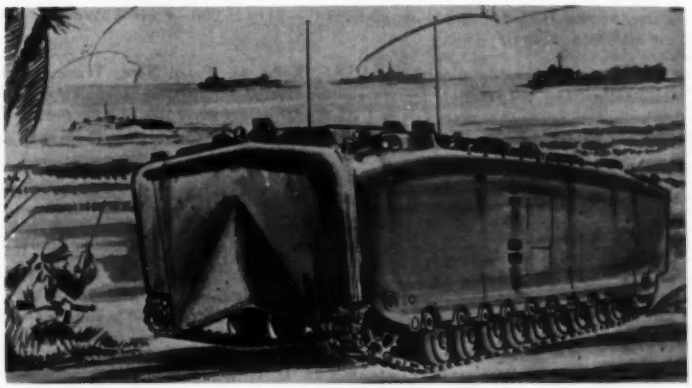
Williams Research, the company widely known for producing the world's smallest jet, now has on test one of the largest as well as one of the smallest automotive gas turbines. Its smallest unit, 75 hp, is to be installed in one of the new Ford Jeeps for US Army Ordnance. (See Page 23, September-October issue of GAS TURBINE.) Williams is also working with Waukesha on a turbine in the 600 hp class. This large automotive turbine is currently on test at Williams research. Looks like Williams is squarely in the automotive field for any practical size.

GT INDUSTRY NEWS



Boeing Industrial Products Division's 430-hp YT60 gas turbine recently completed 50-hour preliminary flight rating test. Individual parts that make up this 325-lb. 2-shaft engine are shown after test. Left to right, Wesley V. Taylor, US Navy Aircraft Engine Lab; William Anderson, Boeing YT60 program manager; E. H. Kirchhof, Office of the Inspector of Naval Materiel; Alfred G. Steinert, US Navy Bureau of Naval Weapons. Navy's official approval of preliminary flight rating for YT60 was based on this extensive detail inspection. It's first and only US turbine in 350 to 450 hp class to receive rating.

Gung Ho . . .
GE's Model 720 gas turbine is slated to power this experimental amphibious landing craft being rebuilt by Jered Industries, Inc., for US Marine Corps. LVTPX-10 functions as troop or cargo carrier . . . or with artillery, as rolling and floating tank. It's 29 ft long, weighs 85,000-lb.



World's Fastest Hydrofoil
US Navy demonstrated this 23-ft hydrofoil at hydrodynamics symposium in The Hague. Boat is being developed for Office of Naval Research by Dynamics Developments, Inc., Grumman affiliate. Called XCH-6, experimental craft is the only turbine-powered vessel with supercavitating foils. Guaranteed speed—70-mph, making it fastest hydrofoil anywhere! Supercavitating propeller is driven by an over-the-stern, right-angle drive shaft-linked to GE's T-58 gas turbine, rated at 1050 hp.

MORE INDUSTRY NEWS FOLLOWS ►

GT CONTRACTS PROCUREMENTS

Some major gas turbine procurements initiated and contracts awarded during recent months by various agencies of the U. S. Government are listed. This material is from the U. S. Department of Commerce publication "Synopsis of U. S. Government Proposed Procurement, Sales and Contract Awards."

• Bureau of Naval Weapons, Washington 25, D. C. "Twenty-one J52-P-6 Engines and fifteen J52-P-6 Engine Containers NOw 60-02-18-i. Amend Nr. 6"—$3,175,000—Pratt & Whitney Aircraft, East Hartford, Conn.

• Bureau of Naval Weapons, Washington 25, D. C. "Sixty-four J75-P-19W Engines with afterburners, thirty-five J52-P-3 Engines; one hundred forty J57-P-59W Engines; and one hundred eighty-five TF33-P-3 Turbo-Fan Engines. NOw 600218-i Amend Nr. 8" —$68,917,277—Pratt & Whitney Aircraft, East Hartford, Conn.

• AMC Aeronautical System Center, USAF, Wright-Patterson Air Force Base, Ohio. "J79-GE-8 Turbojet Aircraft Engines with Afterburners, ninety-four each. Supplemental Agreement Nr. 3 to AF 33 (600)-38852"—$21,150,000—General Electric Co., Flight Propulsion Div., Cincinnati 15, Ohio.

• HQS. San Antonio, Air Materiel Area, USAF, Kelly Air Force Base, Texas. "0241-2840-691-1061 (700438) Nozzle Assy; 0241-2840-769-5627 (578394 Diffuser Assy. in support FY 60 Buyer's Guide Program for J69-T25 Engines AF 01(601)-29832, (PR SA-O-2840-E12588)—474 and 314 each"—$645,223—Continental Aviation and Engineering Corp., Toledo, Ohio.

• Bureau of Naval Weapons, Washington 25, D. C. "Continued General Development Testing of the TF33 Engine. NOw 60-0699-f"—$11,625,000—Pratt & Whitney Aircraft, East Hartford, Conn.

• San Antonio Air Materiel Area, USAF, Kelly Air Force Base, Texas. "Overhaul, modification and preparation for storage and shipment of J-69 Turbojet Engine Fuel Controls, and applicable materials and parts. AF 41 (608)-12059 (PR SA-0-2915-E10051 and SA-1-2915-E15022)—75 each"—$90,375—The Bendix Corp., Hamilton Div., Hamilton, Ohio.

• U.S. Army Ordnance District, Pasadena, Calif. "Prototype Gas Turbine Generator"—$67,000—Solar Aircraft Company, San Diego, Calif.

• AMC Aeronautical Systems Center, USAF, Wright-Patterson AFB, Ohio. "J85-GE-7 Turbojet Engines iaw/Contractor's Engine Specification No. E-1031C dated 21 December 1959, 54 ea., and Data. Use: GAM-72A Installation (PR's EP-0-2840-6868; EP-0-2840-7120)"—$3,456,000—General Electric Co., Small Aircraft Engine Department, West Lynn, Mass.

• Bureau of Naval Weapons, Washington 25, D. C. "One thousand Modification Kits for GTC-85 Compressors in accord with Contractor's Dwg. No. 378157. Letter contract NOw 60-767"—$2,455,000—The Garrett Corp. AiResearch Mfg. Co. of Arizona Div.) Phoenix, Ariz.

• HQS Mobile Air Material Area, USAF, Brookley Air Force Base, Ala. "Gas turbine air compressors, AF type MA-1A, ground support equipment for various first line aircraft and missiles. AF 01 (601)-29811"—364 ea.—$5,635,500—The Garrett Corp. (AiResearch Mfg. Co., of Arizona Div., Phoenix, Arizona.)

• U.S. Army Transportation Research Command, Fort Eustis, Va. "Study and Investigation for the Design and Construction of a Liquid Metal Regenerator for Small Gas Turbine Engines. (DA 44-177-TC-687)-Job"—$99,747—Curtiss-Wright Corp. Research Div., Quehanna, Pa.

• HQS. Mobile Air Materiel Area, USAF, Brookley Air Force Base, Ala. "Duct assy, jet engine starter, 30 ft long, appl to MA-1, MA-1A, MA-2 and MA-3 MSPU power units AF 01 (601) 33480 (01-601-60-1821B)-935 ea."—$278,918—Flexible Tubing Corp. Guilford, Conn.

• AMC Aeronautical System Center, USAF, Wright-Patterson Air Force Base, Ohio. "Starters, Engine Gas Turbine. Type STU-12/A34, AiResearch Model ATSC 10.-1-4, P/N 350950, Aerno 42-8754, Installations for F-105D Aircraft, 61 each, and Data. Contract AF 33 (600)-41053"—$274,517—The Garrett Corp. (AiResearch Mfg. Co. of Arizona Div.) Phoenix, Ariz.

• HQS, Oklahoma City Air Materiel Area, USAF, Tinker Air Force Base, Okla. "Overhaul of J47-GE-17B/33, 25/25A and 27 Aircraft Engines. (RFP-OC-1-02A-009,0012 and 0013)-Job"—$1,745,813—General Electric Co., Cincinnati, Ohio. Competitively negotiated procurement, 2 bidders were solicited and 2 bids were received.

INDUSTRY NEWS...

Company-Reported Contracts

• Many U.S. Government contracts awarded for gas turbines, turbojets, turboprops and parts that came to our attention during the first eight months of 1960 have been listed in GAS TURBINE magazine. All contracts have not been recorded here because of space limitations. A summary of these contracts is presented in the following table.

Engines	$259,000,000
Research & Development	47,000,000
Overhauls & Maintenance	18,000,000
Parts	8,000,000
Tests and facilities	3,000,000
Other	2,000,000
Total	$337,000,000

Some 125 contracts are represented The maximum award in a single contract was $68,918,000. A total of some 2500 engines were purchased.

• Aircraft in a combat readiness status on the flight deck of USS Enterprise, world's first nuclear powered aircraft carrier, will be supplied with cooling air by an unusual application of 16 industrial turbo expanders installed in the flight deck and developed by the **Stratos Division of Fairchild Engine and Airplane Corp.**, Bay Shore, L. I. Stratos has received a $280,675 contract from **Newport News Shipbuilding and Drydock Company**, builders of the 85,000-ton U.S. Navy carrier, for these air cooling units.

• A new $1,300,000 contract for production of an **AiResearch** air turbine generator for the **McDonnell**- built Quail (GAM-72) decoy missile has been announced. Previous contracts totaling nearly $2-million for the units are already being filled. Over half the ATG's 33 lb are in its 3.5-kva. generator. This is directly driven by a single-disc, outward-flow turbine at 24,000 rpm.

• A $32,500,000 production contract has been granted the **General Electric Company** for its J85-5 afterburning jet engine, issued by the **USAF Air Materiel Command.**

J-57 First With Million Airline Hours

Pratt & Whitney Aircraft division of United Aircraft Corporation announced today that its commercial J-57 jet engine has accumulated more than one million hours in airline service—the first jet engine to compile such a record. The twin-spool gas turbine powerplant—which produces 13,500 lb of thrust—powers the first generation of Boeing and Douglas jet airliners which ushered in the US jet age.

Rugged simplicity of the J-57 design has made possible an unprecedented record of reliability in the 22 months since Pan American World Airways flew its first J-57-powered Boeing 707 on its maiden New York-to-Paris flight October 26, 1958.

Boeing's YT60 Under Official Inspection

Boeing Industrial Products Division's 430 hp YT60 gas turbine recently completed its 50-hr preliminary flight rating test. Some of the individual parts that make up this 325-lb, two-shaft engine are shown here being inspected after the test. From left to right are Wesley V. Taylor, United States Navy Aircraft Engine Laboratory; William Anderson, Boeing YT60 program manager; E. H. Krichhof, Office of the Inspector of Naval Material; and Alfred G. Steinert, U.S. Navy Bureau of Naval Weapons. Navy's official approval of a preliminary flight rating for the YT60 was based on this extensive detail inspection. Boeing YT60 is the only U.S. turbine in the 350-450 hp class to achieve this rating.

GE & Small Business

Representatives of nearly 400 small mid-western companies were invited to compete for a share of $200-million in production contracts that General Electric Flight Propulsion Division estimates it will let in 1961. Since 1957, the Flight Propulsion Division has purchased more than 334 million dollars in jet engine components from small businesses similar to those represented at the meeting.

AiResearch Supplies C-130 Accessories

Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona has received orders covering 48 gas turbines, 140 starters and a like number of pneumatic valves. All are for use aboard the Lockheed C-130 Hercules turboprop transport. The giant C-130s which will use the AiResearch units include 12 on order by the Indonesian government, four ordered by Canada and 32 are for delivery to the USAF, Navy and Coast Guard.

Curtiss-Wright Switches To Gas Turbines

Problems with multi-chamber rotary combustion engines is leading Curtiss-Wright to concentrate on low-horsepower, single-chamber power plants and the use of gas turbines where larger power is required.

India Buys Sikorsky Turbocopter

First of two Sikorsky S-62 helicopters have been ordered by India's Air Force. Gas-turbine-powered S-62 is especially suited to high altitude missions, and during evaluation tests in India delivered a 2000-lb payload to a 14,000 ft elevation in the Himalayas, as unprecedented performance for helicopters of this weight class.

Hydrofoil Accessory Power

Scheduled for launching early next spring, the 80-ton, 80-knot, all-aluminum hydrofoil built for MARAD by Grumman Aircraft's Dynamic Developments will use two AiResearch GTCP 85-91 turbines equipped with special light aluminum housings. These units will pneumatically start the aircraft-type turbine prime mover and furnish all electrical power needed on board.

B-70 Jets Controlled by Woodward

The B-70 will be the most advanced bomber ever built anywhere. Control on its General Electric J93 jets is Woodward's 1645 main fuel control—the most advanced control ever to carry the Woodward label.

GT "COMING UP" REMINDER

NOVEMBER 3-4 Society of Automotive Engineers, National Fuels and Lubricants Meeting, The Mayo Hotel, Tulsa, Oklahoma.

NOVEMBER 27-DECEMBER 2 American Society of Mechanical Engineers, Winter Annual Meeting, Statler Hilton Hotel, N. Y., N. Y.

DECEMBER 4-7 American Society of Chemical Engineers, Statler Hotel, Washington, D. C.

DECEMBER 5-8 American Rocket Society, Fifteenth Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.

DECEMBER 17 Institute of the Aeronautical Sciences, Wright Brothers Lecture, Washington, D.C.

JANUARY 9-13 Society of Automotive Engineers, Annual Meeting and Engineering Display, Cobo Hall and Convention Arena, Detroit, Michigan.

JANUARY 16-19 ISA Winter Instrument-Automation Conference & Exhibit, Sheraton Jefferson Hotel and Keil Auditorium, St. Louis, Missouri.

JANUARY 23-25 Institute of Aeronautical Sciences, 29th Annual Meeting, Hotel Astor, N. Y.

JANUARY 29-FEBRUARY 3 American Institute of Electrical Engineers, 1961 Winter General Meeting, Hotel Statler, New York, N. Y.

JANUARY 30-FEBRUARY 3 ASTM Annual Meeting, Chalfont-Haddon Hall, Atlantic City, N. J.

FEBRUARY 19-23 American Institute of Mining, Metallurgical and Petroleum Engineers Annual Meeting, St. Louis, Missouri.

FEBRUARY 26-MARCH 1 American Institute of Chemical Engineers, Roosevelt Hotel, New Orleans, La.

MARCH 5-9 Gas Turbine Conference and Products Show, Shoreham Hotel, Washington, D. C.

Reserved Your Booth?

Reports are that over 25 of the major gas turbine and accessory suppliers have already taken space at the Gas Turbine Conference and Products Show scheduled for the Shoreham Hotel, Washington, D. C., March 5-9, 1961.

GT PEOPLE PLANTS PLACES

Executive Appointments Announced at Allison

Administrative personnel changes in **Aircraft Engine Operations** at the **Allison Division** of **General Motors** have been announced by **J. E. Knott,** director of engineering.

W. G. Emmick, formerly chief test engineer, has been appointed chief of the newly-created Technical Services group and will report directly to Mr. Knott.

G. E. Holbrook has been appointed to head Production Engineering, succeeding **W. C. Oestrike,** who has been named assistant manager of the Reliability Section. Mr. Holbrook will report to **C. E. Hockert,** chief engineer for Turbine Engines, and Mr. Oestrike to **A. R. Townsend,** Reliability manager.

Allison Executive Cchanges

K. H. Hoffman, former Manager, **Transmissions Operation** of the **Allison Division of General Motors** has been named Administrative Assistant to the General Manager, it was announced today by **H. H. Dice,** vice president of General Motors and general manager of the Allison Division. **R. E. Lynch,** Former Manager, Aeroproducts operations of the Allison Division at Vandalia, Ohio was named by Mr. Dice to succeed Mr. Hoffman as Manager, Transmissions Operations in Indianapolis.

Bullock at Dallas For GE

General Electric has announced the appointment of **C. R. Bullock** as Manager of the Southwestern District of the company's Field Sales Operations. Bullock is responsible for the sale of **Flight Propulsion Division** products in thirteen-state area. These include military and commercial jet engines, and rocket and space power units.

Montgomery now Vice President

Appointment of **John B. Montgomery** as a vice president of **General Electric Company** was announced by **Ralph J. Cordiner,** chairman of the board. Montgomery is general manager of the firm's Flight Propulsion Division headquarters at Evendale, Ohio, and reports to **C. W. LaPierre,** vice president and group executive of the Electronic and Flight Systems group.

The Flight Propulsion Division embraces seven major components at the Evendale plant, near Cincinnati, and at Lynn, Mass. The gas turbine business handled under Mr. Montgomery's leadership not only includes all G. E. aircraft turbines, but also the use of those same or similar turbines in marine and industrial service.

GE's Sheehan Moves East

Raymond J. Sheehan has been named manager of equipment support for **General Electric's Aircraft Accessory Turbine Department** at Lynn, Mass. according to an announcement by **J. M. Heldack,** Manager of marketing.

In his newly created position, Sheehan will be responsible for negotiations and administration of contracts for products and services sold by the department and sales of follow-on units, spare parts, special tools and test equipment.

GE's Cavanaugh To Switzerland

A. T. Cavanaugh has been appointed European Technical Services Manager of **General Electric's Flight Propulsion Division** with headquarters at Geneva, Switzerland. Cavanaugh is responsible for field representation on technical matters including large and small jet engines, in England, Western Europe, Africa and the Middle East.

Michael Gluhareff Retires

Carlos C. Wood, 47, director of advanced engineering planning for the **Douglas Aircraft Company, Inc.,** at Santa Monica, California, has resigned to accept the top engineering post at **Sikorsky Aircraft,** a division of **United Aircraft Corporation.**

Wood joined Sikorsky Sept. 1, and on Oct. 1 he became engineering manager, succeeding **Michael E. Gluhareff,** who reaches retirement age on the latter date.

At Sikorsky Aircraft, Mr. Wood will head what is reportedly the largest engineering effort in the helicopter industry.

New Engine-Testing Lab For Socony Mobil

Socony Mobil Oil Co. revealed plans to build a large new engine-testing laboratory for the development of fuels and lubricants for engines of the future.

Nearly doubling Mobil's engine-testing capacity, the facility will be built at the company's research laboratories in Paulsboro, N. J. Twenty test engines will be accommodated, from giant marine and railway diesels to gas turbines, truck and passenger car types. Mobil's scientists will be able to anticipate fuel and lube needs of advanced engine designs years ahead of their commercial production. Other equipment, including a dynamometer, will permit testing of experimental products under all types of weather conditions.

Cooper-Bessemer Changes

William B. Boyum is now Manager of Gas Turbine Sales for **Cooper-Bessemer.** He'll be located at Mt. Vernon, Ohio. Bill Boyum is well known in the gas turbine field. He will have a complete line to handle from large units down to the smaller gas turbines.

Bendix Filter Division Regional Sales Manager

Albert N. Beswick has been appointed Eastern Regional Sales Manager for **Bendix Filter Division** of **The Bendix Corporation** located in Madison Heights, Michigan. **G. T. Grimstad,** Sales Manager of the Division made the announcement. Beswick will maintain offices at the main plant in Madison Heights.

Hiller-Autolite Discuss Merger Plans

Stanley Hiller, Jr., President of Hiller Aircraft Corporation, and R. H. Davies, President of The Electric Autolite Company, announced that they are negotiating to merge the two companies. Hiller is a leading factor in the light helicopter field and Autolite is a major manufacturer of automotive and aircraft parts.

Boeing-Mitsubishi Sign Sales-Service Agreement

Boeing Airplane Company's Industrial Products Division and Mitsubishi Heavy Industries, Reorganized Ltd., have signed a letter of intent covering agreements on manufacture, sales and service of Boeing gas turbines in Japan and the Far East. Formal negotiation leading to final agreements are expected to begin between the Boeing division and Mitsubishi by the end of the year.

N. Y. Area Rep. Appointed By Burgess-Manning

The **Industrial Silencer Division** of **Burgess-Manning** has announced the appointment of **George F. Kelly** as a sales engineer in the firm's N.Y.C. district office. Mr. Kelly was a procurement engineering for the Welding Shipyard Division of National Bulk Carriers.

100-hp Pipe Line Booster

Experimental run of an AiResearch natural gas burning turbine as part of a system to boost gas well head pressure to pipe line pressure started this week in Corpus Christi, Texas. Purpose of the experiment is to provide experience and performance data on natural gas burning turbines for new industrial applications.

New Airesearch Representative For Gas & Petroleum Industry

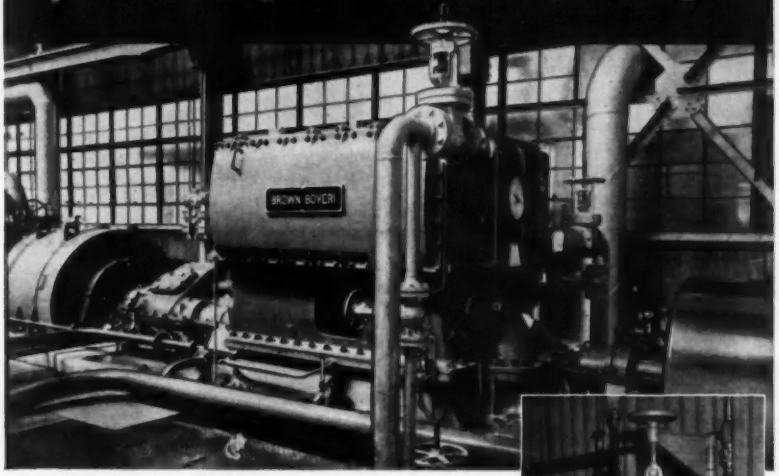
The Oil and Gas Supply Company of Houston, Texas has been appointed a gas and petroleum industry representative for certain AiResearch gas turbines and turbomachinery lines. Agreement was announced jointly by J. J. O'Brien, manager of The Garrett Corporation's AiResearch Manufacturing Division of Phoenix, Arizona, and Jack Joplin, president of Oil and Gas Supply.

USAF Orders 500-Start Turbine

New contract for 295 small gas turbine engines has been received by Garrett. USAF order calls for delivery of 181 of these MA-1A trailer-mounted turbines. Additional 114 units will be delivered in special enclosures for mounting on any standard USAF vehicle. Initially rated for 1000 starts, current turbine models provide 5000 starts before overhaul.

NUGENT FILTER

protects gas turbine bearings



Recharges changed just once a year

One Nugent Filter, Fig. 1555-4L7 handles all the lubricating oil for this 3000 HP Brown Boveri Gas Turbine. Continuous full-flow filtering removes harmful impurities before they can form sludge or acidity. Foreign particles 5 microns and smaller are trapped. Recharges are changed only once a year, due to extended capacity.

Need a single filter or a complete system . . . contact Nugent, today.

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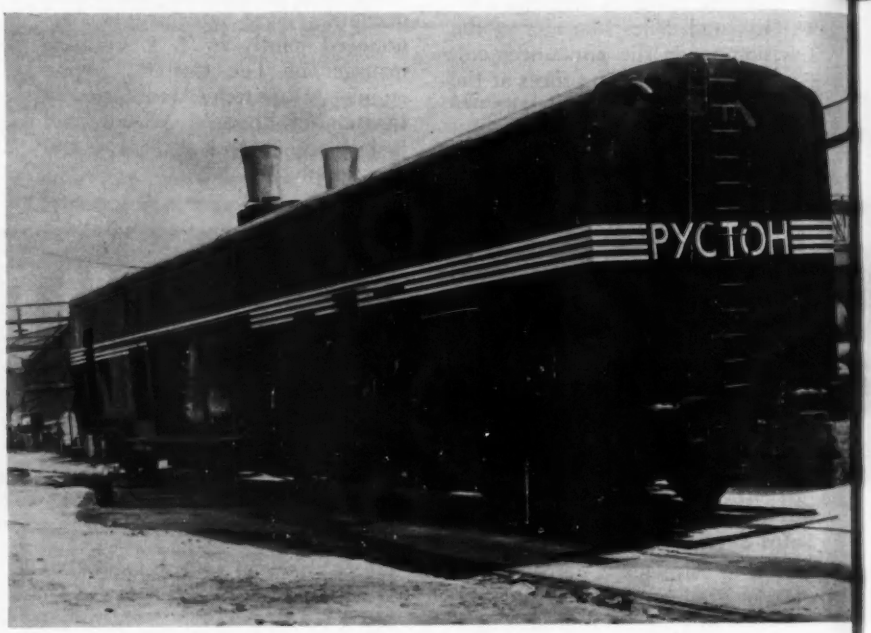


1000-kw Ruston Hornsby portable railway gas turbine delivered to Russia in 1959.

Review of USSR's gas turbine developments aviation...utilities...railways and marine fields

The gas turbine has been thoroughly exploited by Russia in the aviation field as demonstrated in both military and civilian aircraft. Activities in the utilities, railway and marine areas appear to have lagged behind the aviation applications. This is a situation common to other countries. Gas turbines in Russian industrial and military service are discussed.

Aviation

Gas turbines, both jet and turboprop, are widely used in Soviet military and civil aircraft. These aircraft include: transports, strategic bombers, helicopters, tactical bombers, fighters and trainers.

Civil transports with jets or turboprops are equipped with propulsion plants in the following ranges:

14,850 lbt	4,000 ehp
20,950 lbt	12,000 ehp

Military applications cover a variety of aircraft with propulsion capacities up to 19,500 lbt (pounds thrust) and 12,000 ehp (equivalent horse power). Prototype nuclear bomber propulsion plants consist of turbojets of 35,000 lbt and nuclear units with 70,000 lbt.

With the Soviets building one of the most powerful turbojet units, and having done so even before Sputnik, it would seem a simple matter to use these jets for rocket takeoff boosters. With the apparent knowhow the Soviets have in building rocket power plants they have unquestionably perfected the "heart" of the rocket, the gas turbine pumping unit, one of the most important gas turbine applications.

Utilities

A large number of gas turbines are contemplated for the Soviet total power program. These account for about 1% of the proposed 7-year program for 1959-65. One of the most significant problems to be resolved is the successful development of a gas turbine using coal for fuel.

Some 26 gas turbine plants, with a total capacity up to 700 MW are under consideration. Most of these will have 25-MW capacity. However, several will have ratings as high as 50 MW. After 1965, 100-MW generating plants appear likely.

An investigation of a 300,000-kw plant indicates a thermal efficiency in the order of 38%. Data on this plant is as follows:

Capacity, MW	300
Pressure Ratio	78.5:1
T, max.	1300°F
Shafts, Number	3

A schematic arrangement of this design is shown on

Gas Turbine Field

the cover. Plant weight, without ducting and generator, including compressors, intercoolers and turbines is about 1200 tons. Specific weight is estimated to be approximately 13 lb/kw, less generator. Data on compressors and turbines are listed in Table 1 to give an idea as to component sizes.

The above refers to open-cycle plants and studies in the future will include the closed-cycle unit as at this time the world's largest coal-burning gas turbine closed-cycle plant is now operating at Kaschira near Moscow. This plant, built by Escher Wyss, has an excellent efficiency, even at part load. The plant not only generates electric power, 12 MW, but is also used to supply heat to a central heating plant.

This type of plant (closed-cycle) can of course burn any type of fuel. Currently, brown coal of which Russia has large quantities is burned in this plant. Other possible fuels include black coal, peat, gas, oil, even heavy oil, or of course, nuclear heat from a reactor. A schematic of this plant is shown in the lower left hand corner of the cover.

Railway

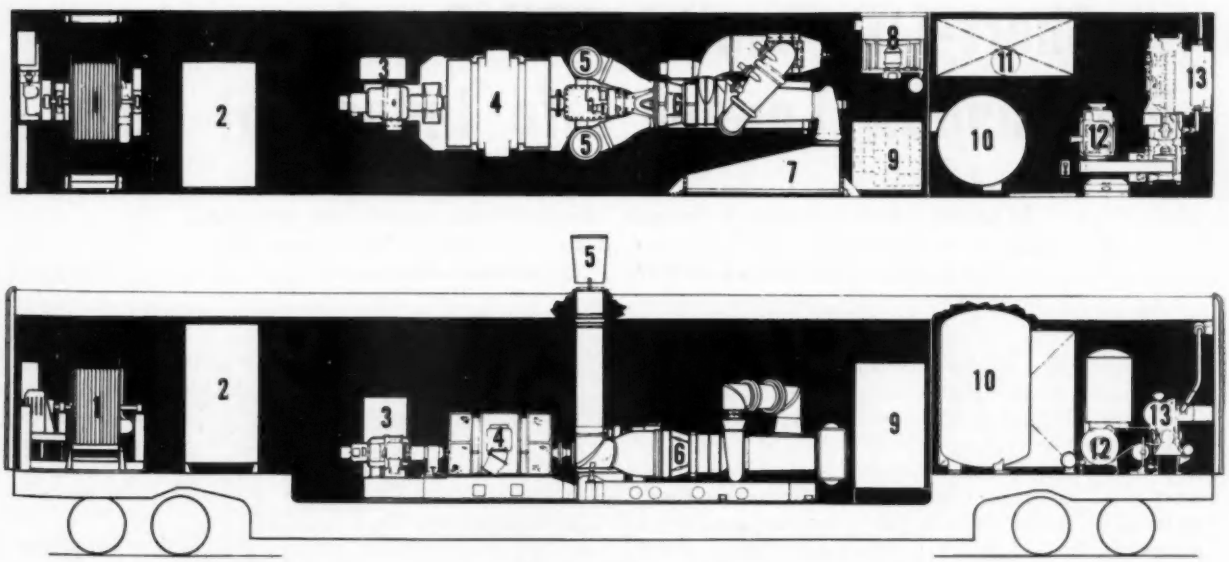
The Kolomna works of the Soviet Union has completed a gas turbine-electric locomotive rated 3500 hp, having two 6-wheel trucks and total weight of approximately 1550 ton. The gas turbine is a single shaft unit, 8500 rpm, 12-stage axial compressor, 6 combustors and a 4-stage turbine. Fuel consumption at full load is said to be 0.73 lb/hp hr, no heat exchanger used. Overall locomotive length is 66 feet including one operating cab. It is proposed to put two of these units back to back giving a total rating of 7000 hp which is in accordance with standard practice in the USA.

Mobile power units on railway cars have also been investigated. A 1000-kw generating set, Figs. 1 & 2, built by Ruston and Hornsby, Ltd., was delivered to Russia in 1959. The set can burn liquid fuel or natural gas.

Marine

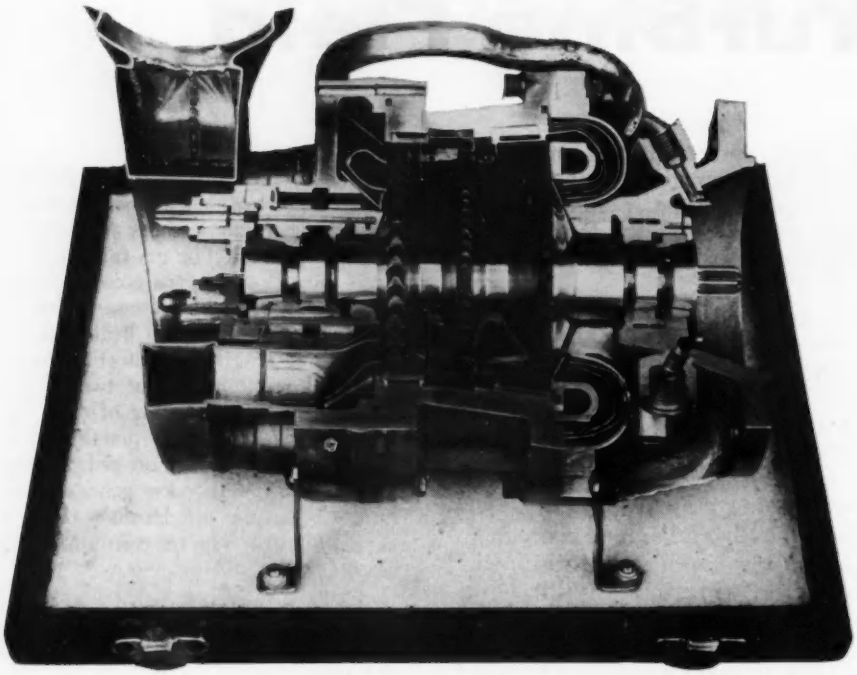
Soviet interest in the marine field has involved both the conventional gas turbine and the free-piston gas turbine. Little information has been made available

(Continued on page 31)



Machinery Arrangement In Ruston Hornsby 1000-kw Portable Gas Turbine

(1) Motor-driven cable drum, which carries 100 yd of armoured flexible 3-core cable for the 1000-kw, 6.6 kv electrical supply. (2) Main switchboard for the mobile power station. (3) Turbine control cabinet, which includes among other items turbine instruments and controls and starting control. (4) 1250-kva Crompton and Parkinson alternator. (5) Twin exhausts for the gas turbine. (6) Ruston 'TA' gas turbine, with 13-stage axial-flow compressor, 'elbow'-type combustion chamber, 2-stage compressor turbine and 2-stage power turbine. (7) Air filter. (8) Lubricating oil cooler. (9) Battery charger and batteries. (10) Compressed gas fuel receiver. (11) Oil fuel tank with 1000-gal capacity. (12) 2-stage compressor for increasing pressure of natural gas to working level. (13) Ruston 6-cyl YDA air-cooled, 110-bhp diesel engine coupled to gas compressor. The 'TA' is started by a battery-fed electric motor.



WK-1131 has rugged, heavy-sectioned blading and rotor.

Short-Life Rocket APU Developments Foreshadow Longer Life Industrial Units

Meeting, even for short periods, the extreme conditions imposed on rocket APU's demands sophisticated design. Here's such an APU with a life of days at 1800°F. Material—Inconel X.

Minutes after countdown, a rocket's gas turbine APU has finished its job. But what a tough few minutes! To insure 100% reliability, actual life capability of the turbine must be very much longer. Also, as in application to orbiting vehicles, required life cycles can be more extended. Design developments that make these turbines live under such extreme operating conditions accrue to the technology of making industrial units, characterized by more modest environmental conditions, live for very long periods.

Walter Kidde and Company holds an enviable record for producing relatively long-life turbines for the rocket age. Their units last for days in actual service, not just hours or minutes. Principally, these turbines have been used in units driven by high-temperature monopropellant gases for use in generating vehicle guidance and control power. Now let's see what some of these turbines can do.

WK1028—This is the first unit built by WK, started in 1949, and the contract with WADC (Wright Air Development Center) ended in 1952. The complete unit is shown. This is a hydrogen peroxide-powered auxiliary power unit with a 4-in. turbine operating at 76700 rpm. The unit is rated 10-hp and meets the following requirements:

(a) Supply 3.75-kva, 3-phase, 400-cps electrical power
(b) Supply 3.5-gpm, 3000-psi hydraulic power
(c) 10-min duty cycle.

WK1131—This is one of the main production units built by WK. Work on this "Navajo" project was from 1953 to 1958. Work was subcontracted from North American Aviation, Inc., who held the prime contract for this missile. The unit's 3-stage turbine is a masterpiece—capable of operating continuously at 1800°F due to its oil-cooled shaft and heavy 4-in. turbine wheels

capable of dissipating the heat and staying together at 80,000 rpm.

This is an ethylene oxide-powered auxiliary power unit for long-range missile application and approximately 50 units were built. Actual flight experience has been very good. This power unit is rated 50 hp and meets the following requirements:

(a) Supply 30-kva, 3-phase, 400-cps electrical power
(b) Supply 7-gpm, 3000-psi hydraulic power
(c) 4-hr duty cycle at rated load
(d) 24-hr hot running life at rated load

WK2000—In 1956 it was decided to redesign and improve the WK1131. The result was this unit. When "Navajo" was cancelled in 1957, work on this was stopped. Only about a dozen of these units were built. This unit is powered by hydrazine and rated 70 hp. It meets the same general requirements as the 1131 unit with the following modifications.

(a) Supply 40-kva, 3-phase, 400-cps electrical power
(b) Supply 8-gpm, 3000-psi hydraulic power
(c) 100-hr hot running life at rated load

WK1160—This unit was sponsored by WADC from 1954 to 1957. It is a self-contained air-to-air refueling pump package in which a JP-4 turbo fuel pump is driven by an ethylene oxide-powered auxiliary power unit. The unit is rated 55 hp and is designed to meet the following requirements:

(a) Drive a JP-4 turbo fuel pump
(b) 20-min duty cycle
(c) 200-hr life

WK325—This unit was sponsored by WK from 1955 to 1957. The single-stage turbine is shown. This is an ethylene oxide-powered emergency hydraulic power unit for manned aircraft. It is rated 25-hp maximum and is designed to meet the following requirements:

(a) Supply 10-gpm, 3000-psi hydraulic power.
(b) 8-min duty cycle
(c) 100-hr life.

WK142—This 25-hp unit was financed by WK from 1958 to 1959. It was purely a design study with no hardware. This hydrazine-fueled power unit is designed to supply electrical and hydraulic power for orbiting vehicles. It employs a turbine drive and is designed to operate underzero "g" conditions and to meet the following requirements:

(a) Drive a 15-kva generator, 8-hp pump, and 1.8-hp blower
(b) 3.5-hr duty cycle
(c) 100-hr life

WK 2146—This unit was privately financed during the year 1959. It is about the only short-life turbine built by WK and proves that WK can build short-life units for emergency purposes as well as long-life units. It is a 6-hp solid propellant-fueled auxiliary power unit and employs a turbine directly connected to a centrifugal-type coolant pump operating at 24,000 rpm. It meets the following requirements:

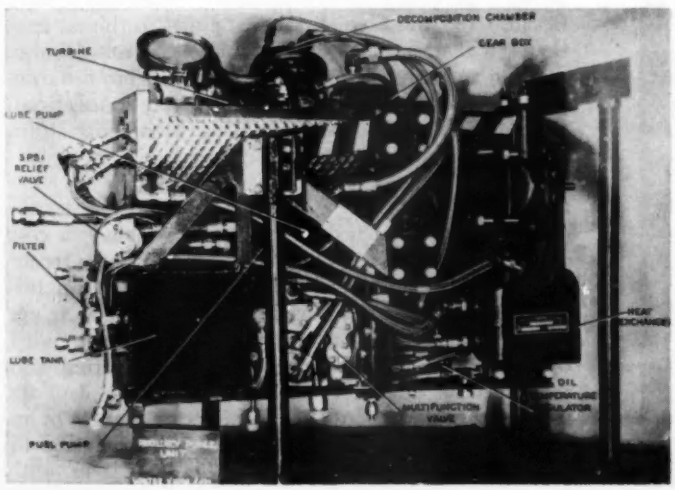
(a) Supplies coolant at 26.5 gpm, 170 psia
(b) Operating time, 45-50 sec
(c) Life, 250 cycles of ¾ min duration

Summary

Monopropellant-fueled auxiliary power systems are non-air breathing devices and, therefore, are not limited in altitude. However, performance is affected by exhaust pressure experienced, performance generally being better at low exhaust pressures. Turbine drives of this type can be designed for any altitude which means the WK units can be used for orbiting vehicles.

Orbiting vehicles must have APU equipment of the lightest weight but at the same time this equipment must be rugged and unquestionably reliable. The past 12-yr of Kiddie's APU development and production programs show that their equipment is well suited for future use where reliability is a must.

Important as these rocket age applications are, their design and development has other far-reaching effects. An apt parallel is seen in the solid benefits that accrue to passenger car design from high-speed and endurance racing. The fact that these APU's can live under the extreme operating conditions, with relatively unsophisticated metals used in their construction, shows important technological gains. And these can apply to the whole range of gas turbines.



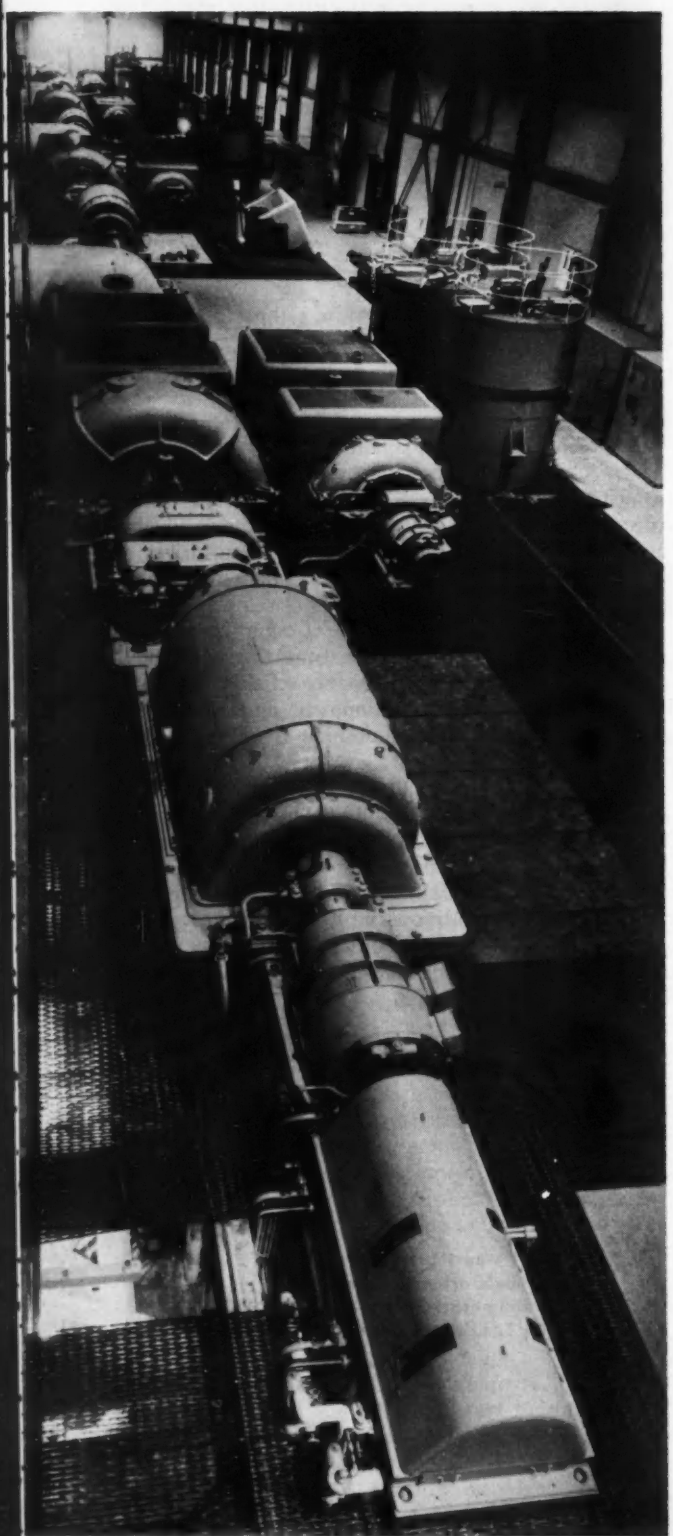
WK-1131's auxiliary power supply assembly is capable of operating continuously at 1800°F. Ethylene oxide-powered.

Operating Report:

Gas Turbines Firm-Up Hydro-Electric System

Natural gas-burning Brown Boveri gas turbines supply 134,000 hp —world's largest generating plant!

by **Dr. T. Ingledow**, President
International Power and
Engineering Consultants Limited
Vancouver, B. C., Canada



World's largest gas turbine generating plant is now operating on the British Columbia Electric Co. system. The 4-unit 100-Mw plant at Port Mann, commissioned September 25, 1959, is fully automatic and unattended —being controlled remotely from the head office in Vancouver 15 miles away.

The Port Mann plant has three main functions:

1. To firm up capacity of the large hydro system from critical to median water condition. During low water conditions, the plant will be operating at high load factor; at other times, it will run at reduced output or be shut down altogether.
2. To meet unforeseen peaks.
3. To serve as emergency source of power.

Important Advantages . . .

For these functions a gas turbine plant has several technical advantages over a conventional steam turbine plant. Units require only 20 minutes from a cold start to full load as against 4 to 6 hours for a steam plant. Because of their basic simplicity, gas turbines lend themselves to automatic and remote control. A minimum of auxiliary equipment is required. They are compact and do not need heavy and elaborate foundations. Considerably less cooling water is used than with steam turbines. Construction time is shorter.

Cost . . .

Port Mann's gas turbine plant is estimated to cost about $12,800,000, or $128 per kw. By contrast, a recent survey in the United States indicates that steam turbine plants of 100-Mw capacity would average $145 per kw exclusive of switchyard; and automatic unattended operation is not possible at present. Operating and maintenance costs for an attended gas turbine plant are estimated to be 80% of those for a steam plant. For an unattended gas turbine plant this figure is reduced to 50%, including fixed charges for investment in addi-

tional control equipment. Maintenance will be provided by mobile squads of servicemen.

Long-term average load factor of this plant will be quite low—15%—due to being operated with a hydro system. On this basis gas turbines are more economical than steam turbines over a wide range of fuel costs ranging from 20¢ to 60¢. Any higher fuel costs are more than offset by low capital charges, operating and maintenance costs.

Fuel . . .

Primary fuel is natural gas, supplied on an interruptible contract. At full production, the station burns 44-million cu ft daily. When gas supply is cut off, turbines will run on crude oil. Natural gas has a decided operating advantage compared to oil—there is virtually no fouling of turbine blading, consequently reducing maintenance outages for washing and cleaning.

Gas is supplied directly to the turbines through a 12-in. line fed from the 24-in. line next to the east property line. Crude oil is supplied through a 12-in. line from the Transmountain pipeline 1400 ft west of the plant site. A dyked storage area encloses a 100,000-bbl bulk storage tank and a 24,000-gal crude oil "day" tank. There is a 24,000-gal diesel oil tank for the stand-by generators.

Turbines . . .

The four Brown Boveri gas turbine units are placed longitudinally in the power-house to minimize width of the structure and the excavation for forming the bench on which it is situated. Each unit is supported at the operating-floor level by an independent steel structure on independent foundation blocks. Operating floor around the unit is of reinforced concrete supported by a steel structure.

All four machines are 2-stage, 2-shaft, reheat, intercooled, open-cycle units, rated 25,000 kw at 25°F air temperature, and 21,600 kw at 70° F. The greatly increased output at low ambient temperatures is useful to meet peak loads during cold snaps.

Air is drawn through sinusoidal silencers within reinforced concrete air-intake structures and enters the low-pressure compressors. From the low-pressure turbine, gases are discharged through the exhaust stack to atmosphere with about 70% of the oxygen unburnt. Combustion chambers are arranged vertically at the side of each unit. Fuel is injected at the top. As upper portions of the chrome-steel heat-resistant liners are subject to the highest temperatures, this section is formed of replaceable metal tiles to facilitate maintenance.

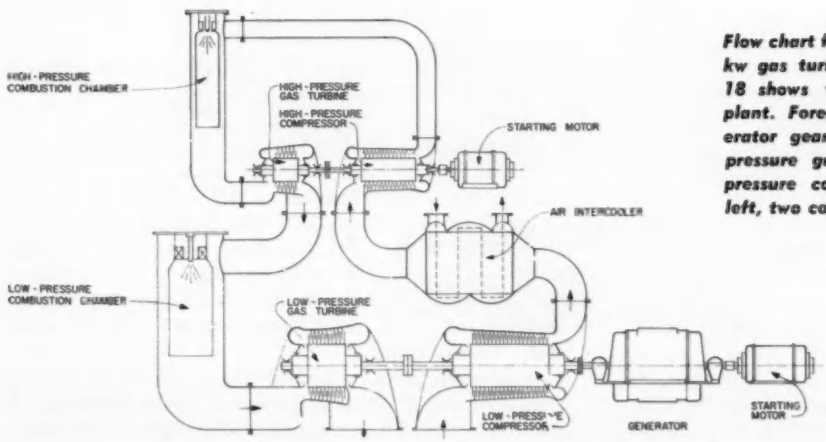
Each shaft has a governor with a gear-driven, spring-loaded centrifugal-type speed-sensing unit controlling hydraulic servo circuits. The low-pressure-shaft governor holds correct governor speed regardless of load on the set. High-pressure shaft speed adjusts itself automatically to load, varies from 3600 rpm at no-load to 4500 rpm at full load. Something unique maximum governing sensitivity is attained by a pulsator which induces pressure waves in the governing oil system. This causes the fuel regulating elements to oscillate minutely and thus overcome some friction and inertia that might delay response.

An automatic temperature-controller enables each of four units to carry maximum load at any ambient temperature without exceeding the predetermined maximum turbine inlet temperature of 1200°F. Protection against overspeed is provided by the governor. In event of governor failure, an emergency overspeed governor unloads the governing oil system within one second.

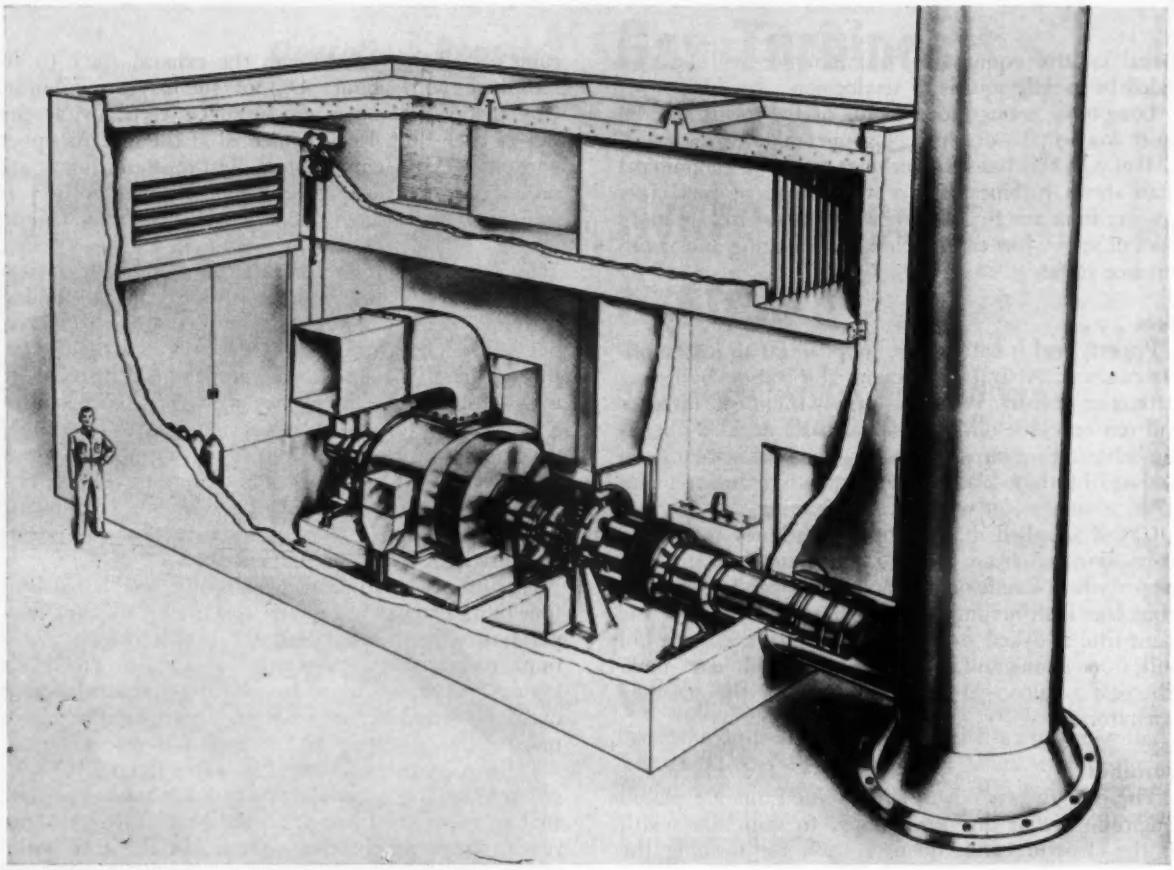
Plant requires 24,000 gpm of water to cool the four gas turbine units. Considerable care was taken to ensure that no harm would come to the Fraser River salmon-run through use of this volume. Intake and outlet structures comply with requirements of the Department of Fisheries and the International Joint Salmon Commission.

Two 4,180,000-Btu per hr hot-water boilers (operating at 60 psig and 200°F) supply heat for turbine fuel oil preheat and maintain building temperatures. Combustion equipment provides for automatic, operation on crude oil or natural gas. Provisions have been made for installation of a third boiler—required if bunker-type heavy oil is used as turbine fuel. Boiler operating pressures would then be raised to 150 psig and the operating temperature to 365°F for adequate heating of the heavy turbine fuel oil.

(Continued on page 30)



Flow chart for one of Brown Boveri's 25,000-kw gas turbine units. Photograph on Page 18 shows whole Port Mann 100,000-kw plant. Foreground, No. 1 25,000-kw generator geared to its compressor and low pressure gas turbine. On the left, high pressure compressor and turbine. Further left, two combustors.



Typical Bristol Siddeley 3 Megawatt automatic turbo generator.

"Pocket-sized" Plant for Power Peaking

Modified turbo-prop engine powers generating station for emergency and peak-load service. Control is both remote and automatic.

by J. Grindrod

A remotely and automatically-controlled "pocket" power generating station has recently been placed in service in Britain. Prime mover is a 4250-hp modified land version of the Proteus turbo-prop engine. Placed in service by the South Western Electricity Board, it is claimed to be the first installation of its kind and size in the world.

By dialing a telephone number in the Board's control center in Bristol, the generator is connected to start the turbine. This takes place 100 miles away at Princetown on Dartmoor, Devon. Within 2½ minutes from a cold start Britain's only unmanned "pocket" power station steps up to full power. The generator is capable of supplying a town of about 10,000 people under emergency and peak-load conditions.

This lightweight Bristol Siddeley 3000-kw turbo-generator represents a significant breakaway from the conventional methods of electrical generation. It gives the advantages of low capital cost, fully-automatic operation with remote control for starting and shutting down, instant readiness at all times, high reliability and low maintenance costs. Plus this—the unit is both compact and entirely self-contained.

A Proven Prime Mover

The Bristol Siddeley Proteus from which the set's prime mover was developed is still claimed to be the most powerful turbo-prop in international airline operation. Also, it has a specific fuel consumption among the lowest of any gas turbine engines in service today. The engine has nearly a million hours running experience behind it and has an approved life between overhauls of 2000 hours.

As a result of an admiralty contract for a marine version of the Proteus to power a class of fast patrol boats, the engine has been adapted to operate on diesel

oil. It has thus benefited from development programs which, in scale, variety and severity, exceed anything that could have been justified for any engine designed specifically for industrial purposes.

Engine Description

The reverse-flow gas system of the Proteus provides a simple, short, compact free-turbine 2-shaft unit, without heat exchanger. It attains a high thermal efficiency through use of advanced compressor and turbine designs and a compression ratio of 7.3:1. In conformity with the Bristol Siddeley "free turbine" principle, the compressor and power turbines are mounted on concentric but mechanically independent shafts.

Air enters radially through passages in a light alloy casing just to the rear of engine center and travels forward through 12 axial compressor stages to a single centrifugal stage, where it flows outward. On leaving the compressor, the air is turned rearward into eight tubular combustion chambers arranged around the compressor casing. Here, fuel is injected and burned.

Combustion gases discharge through four turbine wheels coupled in pairs. The first pair drives the compressor and the second pair drives the output shaft through a compound epicyclic reduction gear at the front end of the engine. This reduction gear is similar to that used on the Proteus aero-engine. It has proven very reliable in service and has been tested successfully at much higher powers than are developed by the turbo-generator engines.

All engine accessories, whether driven by the compressor or by the power turbine system, are grouped around the engine's front end. Exhaust silencers and intake baffles reduce the noise level.

The control system is designed to hold fuel flow and power constant at ambient temperatures below 30°F. Above this temperature the set runs at constant compressor speed, giving a maximum output which varies with air temperature. Maximum power is thus available in cold weather when it is most likely to be needed. For peak-load generation, there is no need to run at less than the indicated powers in order to obtain reliable or economical operation as is often the case with piston engines, and no provision is made for doing so.

There are protective devices to prevent overspeeding and to stop the engine in case of pressure failure in either the oil or fuel systems. Detectors are provided which shut down the engine and discharge carbon dioxide extinguishers in case of fire.

The gas turbine's twin-shaft arrangement enables each system to run at its optimum speed under all conditions and, furthermore, has three valuable advantages in turbo-generator application.

First, power required for starting is relatively low because only the compressor system is rotated; Second, the alternator is coupled to a unit of low inertia which facilitates automatic synchronization; and third, the engine can meet an overload by putting out a higher torque at reduced speed without loss of power or risk of stalling.

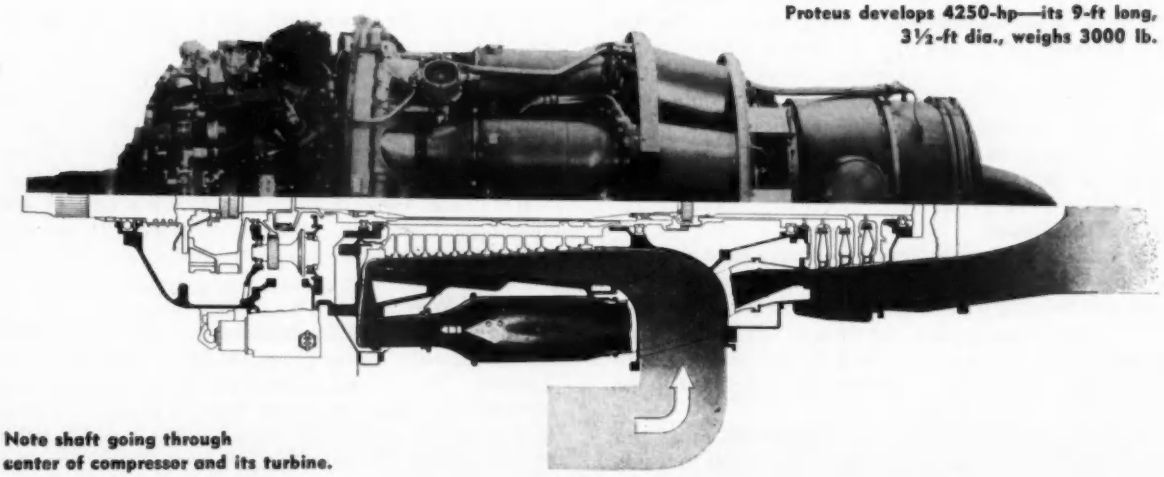
Housing and Installation Simple . . . Economical

The "pocket" power station is no bigger than a very small house, thanks to the compactness and low weight (little more than a ton) of the turbine. Since the engine requires no cooling water an alternator with direct air cooling, (manufactured by the Electric Construction Co., Ltd. of Wolverhampton, England) was selected. Space requirements and complication of cooling towers, heat exchangers, etc. is thus eliminated.

No space heating of the building is required either for alternator or engine. Heaters are built into the alternator to ensure that windings are kept dry and warm at all times. This elimination of space heating makes it unnecessary to provide automatic shutters on the engine air intake or, indeed, on the alternator ventilating air inlets.

Low Maintenance Promised

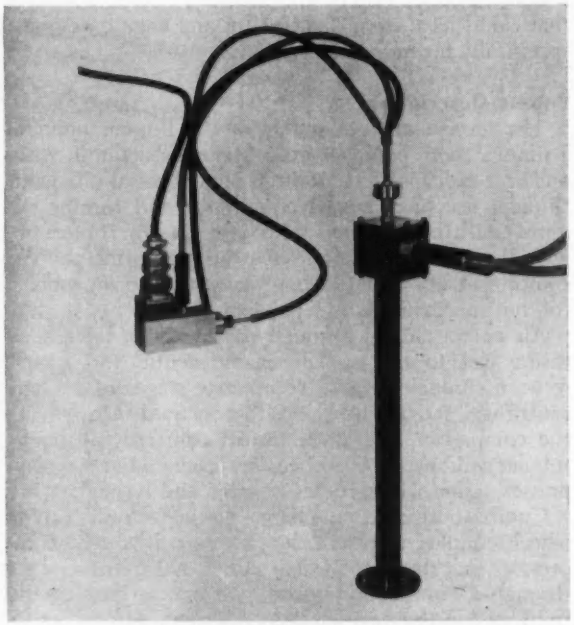
Very little maintenance is expected for this type of industrial turbine. After every 100 hours of operation the filters should be inspected, the plant run and instrument readings logged. This should also be done in the autumn if the plant has not been used during the preceding summer. Initially, the engine should be removed for inspection after 1000 hours running but it is expected that later, based on the findings, this period will be increased to 2000 hours or more.



Proteus develops 4250-hp—its 9-ft long, 3½-ft dia., weighs 3000 lb.

Note shaft going through center of compressor and its turbine.

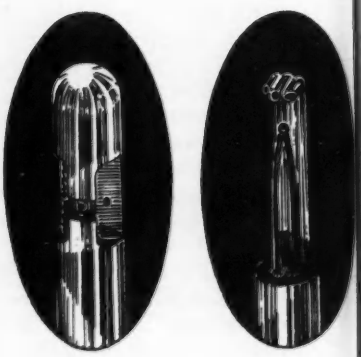
"EDUCATED" PROBES get flow data



Receiver (positioner) and pressure transducer.

New development tools and techniques for obtaining gas-flow data, remotely and automatically, on operating axial compressors and turbines.

by E. M. MOFFATT
Chief Engineer, United Sensor & Control Corp.



A B

With growth of the gas turbine industry, designers were faced with the problem of measuring variables, measurement of which defied their current techniques. Another problem was predicting airflow patterns under conditions which were impossible in the light of existing theoretical knowledge. For example, in the axial flow-type compressor used in modern, efficient gas turbines, flow angles at each stage of blading must be controlled and predicted to an accuracy of about one degree.

Today, most manufacturers are gradually adopting the solution of combining theoretical aerodynamics equations with correction factors obtained from actual measurements on operating turbines. The only practical way to measure the velocity and flow angle in the restricted space between blade rows is with direction-sensing airflow probes.

Early Techniques

In early development programs, cylindrical types of sensing probes were used. These had three pressure taps approximately 50 deg apart at one cross-section. They were moved in and out of a 1/8-in. hole drilled in the case of the compressor and rotated by hand until the pressure difference between the outermost holes was zero.

At this point the angle indicated by the protractor on the probe was read and recorded and total pressure, indicated by the centerhole, also recorded. While this method gave accurate results it was very time-consuming and often was impractical or impossible for safety reasons, particularly on new turbines operating at high power. Needless to say, quality of data gathered under these conditions was not to the highest scientific standards.

It became obvious that to take advantage of this measuring technique, probes would have to be controlled remotely.

A Better Way

One solution to this problem is a traversing mechanism currently being produced by United Sensor & Control. This is an all-mechanical positioning unit mounted on the turbine itself. A motor box is connected to this by special flexible cables and is located within approximately 10 feet of the positioner. A transmitter

is located any distance up to 100 feet or more away from the motor box and is connected to it by an electrical cable.

Remote position indication is by means of heavy-duty selsyns in the motor box and transmitter and by direct mechanical positioning between the motor box and receiver. Angle and position of the probe are set by pushbutton controls on the transmitter and are indicated directly in thousandths of an inch and tenths of a degree on direct-reading counters.

Then Came Refinements

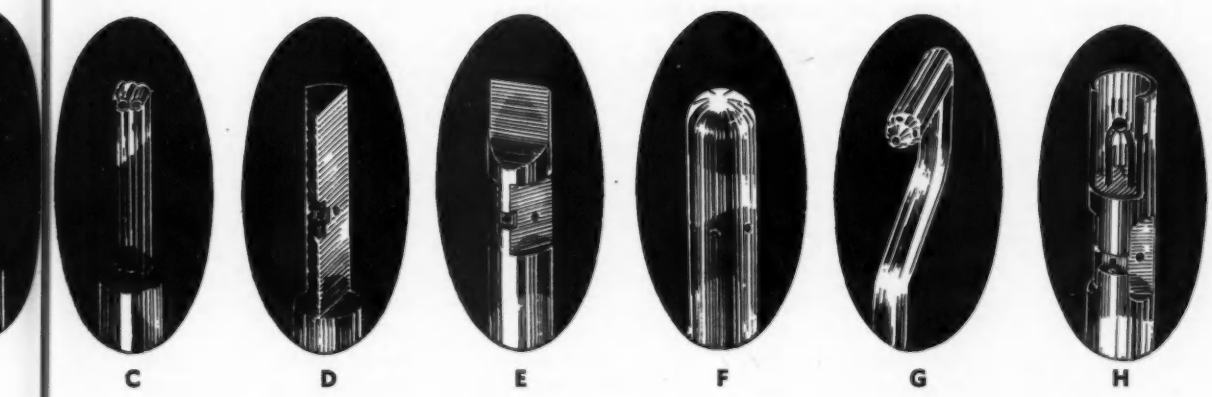
After various types of remote positioning units were developed it became obvious that the biggest time factor involved in taking data was the time it took the operator to rotate the probe to balance out the yaw pressure differential. Time constant of the probe for this balancing operation depends partly on size of the internal passages in the probe and partly on displacement volume of the U-tube or manometer. The quickest way to decrease the time constant is to replace the water U-tube with an electrical diaphragm-type gauge mounted directly at the outlet of the probe.

However, to decrease time and improve accuracy still further, various types of automatic positioning units were developed which would use the output of the electrical gauge to rotate the probe itself so that the operator had only to position the probe in the rig and record the angle and other pressure measurements.

The units transmitter uses output of the electrical pressure transducer connected to the yaw pressures to rotate the probe automatically and keep the differential equal to zero at all times. When properly set this unit will automatically rotate the probe to zero pressure difference within two to five seconds from an unbalance of ten degrees or more, down to velocity pressures as low as 1 inch of water.

Aid to Design

This instrumentation technique does not, of course, furnish advance information on an unkown design; it can only be used to correct mistakes in an existing design. So from a new development standpoint it is still a laborious task to analyze airflow through an axial compressor. However, with the accumulated experience of several development tests it is possible to correct design equations used to set the proper blade angles initially. Then this technique serves as a constant check on theoretical design work that goes into building an axial compressor or turbine.



A, has 5 pressure holes and is used for measuring total and static pressure as well as yaw and pitch angle of flow, especially useful where the plane of the flow is not perpendicular to the axis of the probe. Minimum size hole for installation is 1/8".

B, is a combined pressure and temperature probe for measuring total pressure and temperatures and yaw angle, especially useful in boundary layers. Minimum size hole is 5/32".

C, is a similar probe without the temperature element. Minimum size hole is 1/8".

D, is a wedge probe for total and static pressure and yaw angle measurements. It is less sensitive to pitch angle and more accurate for static pressure in general than type A. Minimum size hole is 3/16".

E, is a 3 hole probe for measuring yaw angle and total and static pressure where the flow is not in a plane perpendicular to the axis of the probe. This can be installed through a 1/8" hole.

F, is a cylindrical yaw probe with 3 holes used for measuring total pressure and yaw angle when the plane of the flow is perpendicular to the axis of the probe, not recommended for static pressure. Minimum hole size is 1/8".

G, is a 5 hole probe for measuring the same flow properties as Type A but is more accurate in boundary layers. However, the overhanging tip makes it more awkward to use. This requires a minimum installation hole of 3/4".

H, is a combination 5 hole pressure probe and thermocouple similar to Type A, except that it measures temperatures as well as the other properties. Minimum hole size 3/16".

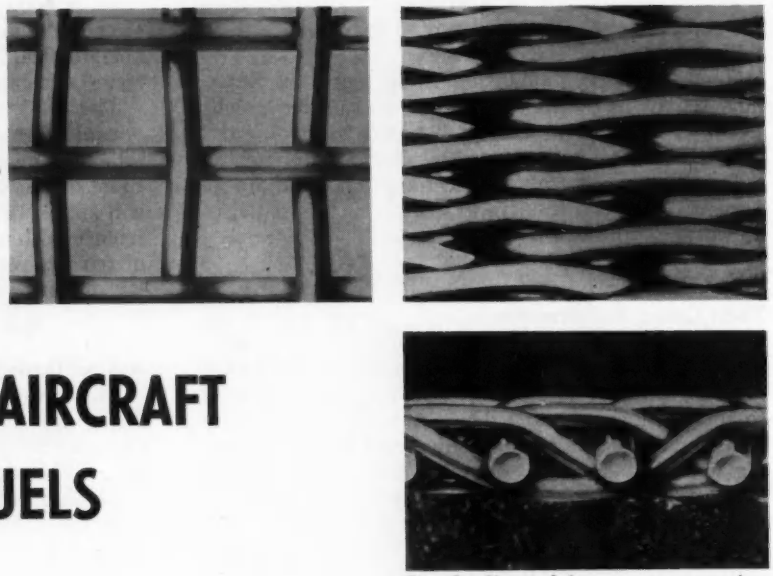


Fig. 1—*Upper left: square weave (enlarged). Upper right: Dutch twill weave, top view (enlarged). Lower right: Dutch twill weave, sectional view (enlarged).*

FILTERING AIRCRAFT TURBINE FUELS

Filtration problems in airborne gas turbines and an approach to their solution.

by Marcel G. Verrando
Assistant Chief Engineer
*Aircraft Porous Media, Inc.**

As reliability of aircraft gas turbine engines steadily increases, major trouble areas become more apparent and consequently are receiving increasing attention from design engineers. Among these new areas is the problem of fuel cleanliness and filtration techniques.

Advances in engine and airframe design place ever-increasing restrictions on the choice of filtration materials. Choice is limited to those capable of maintaining physical and filtration properties when exposed to a combination of extreme temperature and severe shock and vibration—conditions that exist in airborne gas turbines.

Until recently it was necessary to design turbines around the limitations of filter media, rather than requiring media to meet optimum requirements of gas turbine operation.

There is, however a filter medium which is capable both of providing an absolute degree of filtration and of withstanding the harmful effects of the gas turbine environment. This medium is sintered woven wire mesh. Other media are often capable of providing either absolute ratings or of withstanding the gas turbine environment but usually not both.

Recognition of the ability of sintered woven wire mesh to perform satisfactorily in gas turbines has led the following major American manufacturers of gas turbine aircraft engines to specify this medium in fuel filters used on their engines: General Electric's CJ-805-3, J-79-7, and J-85-5; Pratt & Whitney J-75 and Lycoming T-55 engines are all equipped with fuel filters in which woven wire mesh is the filter medium.

A Sintered Filter—What and Why?

Sintering is an accurately controlled temperature process that produces a fusion bond at the contact point of each cross-wire in the woven cloth, thus increasing rigidity and making permanent the size and shape of pore openings in the mesh. Sintered wire cloth can be made from a number of materials. However, AISI 300 series stainless steel is the most widely used for aircraft applications because of its good corro-

* *Subsidiary of Pall Corporation, Glen Cove, N. Y.*

sion resistance, high strength and general suitability for weaving and fabricating.

Wire cloth is classified as a "surface type" filter medium; that is, contaminants are collected on the surface rather than within the internal structure of the medium. There are two weaves especially suitable for filtration purposes. These are the plain weaves (suitable for mean pore openings down to 25 microns) and the dutch twill weaves (extending the mean pore opening range down to 9 microns). See Fig. 1.

Properly sintered wire mesh permits no media migration. Since all wires are fused at their contact points, there are no loose ends to break off. Sintered mesh also prevents shifting of the wires when exposed to differential pressures, thus preventing passage of already collected solids. Corrugated cylinders shown in Fig. 2 & 3 offer large area in small volume. It produces compact, light-weight units with the low pressure drop, coupled with container-economy in collection of dirt and other foreign matter.

Approach to Specification

Specifying filters and strainers by mesh count alone can lead to serious inadequacies in actual use because the specification is obviously incomplete. Approach should be in the opposite direction as it's entirely possible that an adequate filter specification could exclude any consideration whatsoever of mesh count. Desired filtration properties under specific conditions could be specified and from this criteria, the optimum mesh count for the purpose determined.

Screens and filters preferably should be specified by nominal pore opening size in microns, maximum particle removal rating, and by a minimum dirt capacity using a specified contaminant. Design engineers can then ask filter manufacturers to find the best filter to meet the particular design requirements.

Another point, seldom does a filter designed for one application meet the needs of another. General Electric's, J-79 turbo-jet engine series provides an excellent example. In each of four models of that engine, a different set of filters is used. For example, Figures 2 and 3 show the fuel filters, manufactured by Aircraft Porous Media, Inc., a subsidiary of Pall Corporation, used on the J-79-7 and J-79-8 engines. Note how different they are; the other two are equally different. Several are equipped with "DELTADYNE" differential pressure indicators providing visual indication of excessive pressure drop. This signifies when accumulated dirt has reached the point when the filters should be removed for cleaning.

In conclusion . . .

Sintered woven wire mesh is a filtering medium for gas turbines that can cope satisfactorily with the dual problems of getting optimum filtration and providing physical characteristics suitable for meeting extreme environmental conditions.

In specifications, requirements placed on the filters are often unrealistic, sometimes even contradictory. A more realistic approach is to state the filtration requirements under all operating conditions. Such specifications, in addition to spelling out environmental and operating conditions, should also include absolute and nominal filtration rating desired and include a dirt capacity test requirement to be performed under specific conditions.

Then let the filter manufacturers meet the specification. Recognition by design engineers that high-level help in this specialized field is available will make his own job considerably simpler. By placing the filter design job in the hands of any of a several dozen filter manufacturers, the turbine engineer will get a better filter . . . and a better turbine.

Fig. 2—Filter designed for use on prototype J-79-5 engine.

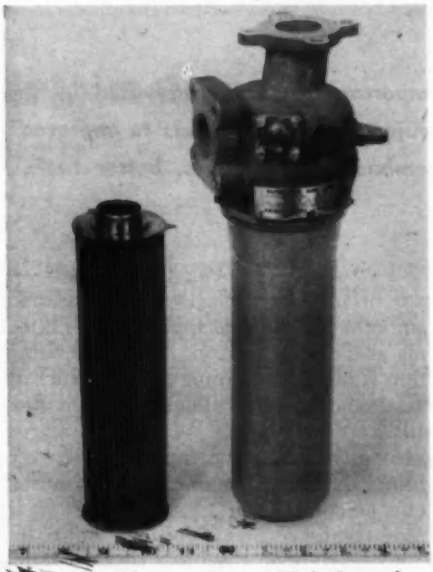
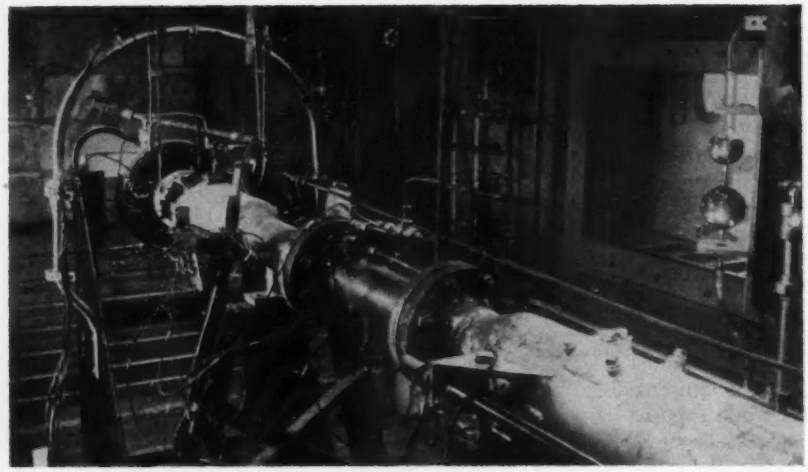
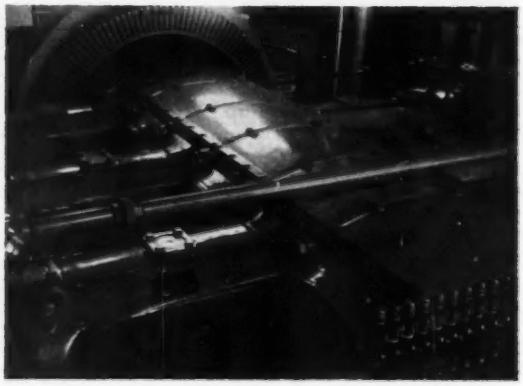


Fig. 3—Filter used on J-79-8 General Electric engine.



Fully-instrumented combustor mounted in test cell to study effects of fuel characteristics. Air enters from lower right, is supplied by Cooper-Bessemer reciprocating compressor seen below.



Texaco Researches Turbine Fuels

Important research conducted by this major oil company leads to improved combustion techniques, better fuels

Behavior of fuels and effects of their characteristics in jets and other gas turbine applications is under intensive study at Texaco's Beacon, New York, laboratories. Evaluation is made by burning different fuels in actual commercial combustors of different design and observing results.

Objective is to determine the effects of various fuel composition-combustor combinations with respect to such items as combustion . . . efficiency . . . deposits . . . nozzle coking . . . corrosion . . . smoke and odor. Environmental tests on the fuel's thermal stability and the effects of a fuel's flame radiation (luminescence) characteristics are also included.

Combustion air is provided by electrically-driven reciprocating compressor. Some 1180 hp can provide air in three pressure and flow ranges: (1) 42,000 lb/hr at 25 psig; (2) 24,200 lb/hr at 100 psig; and (3) 16,400 lb/hr at 285 psig. Use of a second available compressor can boost pressures if needed. Out of this research comes more knowledge for better gas turbine fuels as well as data on the effects of combustor design.

Background information received from Texaco's basic research programs, enables Texaco to handle the many problems coming in from accounts throughout the world. Recommendations for better utilization of available fuels can be made. Or, specific fuel variations dealing with a particular account can be run in one of the laboratory's simulated "rigs" to check out proposed recommendations.

Solution For Turbine Smoking . . .

An interesting example of a specific fuel problem involved smoking problems on a large gas turbine at an inaccessible location abroad. Fuel supplied was local and its source could not be changed. Laboratory data, already on hand, indicated that the following changes should improve this condition.

1. Heating the fuel to a higher temperature to improve atomization.
2. Raise inlet air tempertaure to further help vaporize heavy fuel.
3. Increase the surplus air.

These recommendations were made to the customer and his problem was minimized.

Texaco, likewise, has a number of testing units to develop basic information on lubrication problems. Again, such information is applicable to the lubrication problems encountered in gas turbines.

The above is just a very brief report on the extensive research that Texaco is conducting on both fuels and lubricants for all sizes of gas turbines.

Montana-Dakota Utilities Company gas turbine and steam plant at Williston, N. D., showing in the foreground one of Burgess-Manning's huge silencers. Other silencer is on opposite side of the plant.

Silencers make Gas Turbines "GOOD NEIGHBORS"

Utility quadruples generating station capacity with two gas turbines yet lets nearby residents sleep undisturbed, thanks to effective silencing.

Two of the largest silencers ever built are installed at the Montana-Dakota Utilities Company electric generating station at Williston, N. D. The plant backs up to one of the better residential developments of the city. When two gas turbines were installed, the utility took steps to insure that residents in the area would have no cause to object to any noise generating by the turbines. Enter Burgess-Manning engineers who designed the giant silencers for this installation.

And they are big. Designed and built by the Burgess-Manning Company of Dallas, the snubbers have a 12-ft diameter, stand 74-ft high and weigh 70,000-lb. It was necessary to break down the units into three sections and ship components on two flat cars per snubber.

Why Gas Turbines?

After the Williston Basin oil field was brought in, resulting increase in population and business activity and the consequent increased demand for electrical power began to overburden the 2000-kw steam plant operated by the utility. It tied in with other steam plants in Glen Drive, Montana, and Columbus, N. D., and with power supplied from the government-operated hydroelectric plant at Fort Peck, Montana.

To increase capacity, the company elected to install gas turbines for four principal reasons. First, a gas

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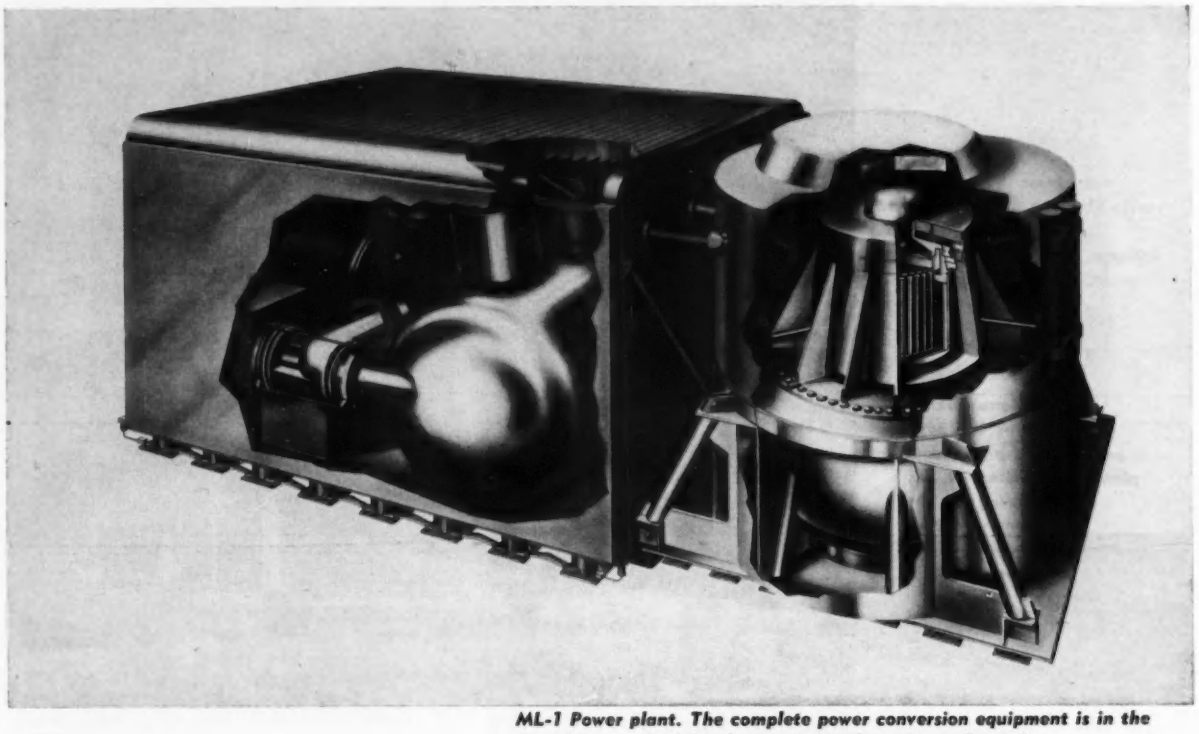

ML-1 Power plant. The complete power conversion equipment is in the container on the left, the reactor is the unit on the right.

Army Building Gas Turbine - Nuclear Power Package

Gas-cooled reactor combined with closed-cycle gas turbine produces a mobile, low power-level nuclear power plant.

"ML-1" is the US Atomic Energy Commission and Army terminology for a mobile low-power nuclear power plant. This plant is divided essentially into four packages: the two shown, plus the control system and necessary auxiliary supply skid. Both the reactor package and power conversion equipment are supported by individual, independent frame and shock mount systems.

Basically the reactor is a high-temperature, gas-cooled unit, coupled with a closed-cycle gas turbine to form a mobile power system. Control of this plant is effected from a control cab located some 500 feet from the reactor. The auxiliary supply skid will contain necessary water-processing equipment, maintenance tools, and a reserve supply of coolant gas.

The program must solve three major engineering problems: 1) development of a reliable, long-lived fuel element; 2) development of a gas turbine-driven power conversion system; and 3) design and construction of the reactor package assembly.

Power Plant Operating Requirements

At ambient temperatures ranging from −65 to 100° F, nominal output will be in the range of 300 to 500-kw. At ambient temperatures in excess of 100°F or during high-altitude operation, operational output is limited by performance of the pre-cooler.

Because the power plant must be transportable by railroad, truck trailer or aircraft, weights and sizes of components are definitely limited. The skid containing power conversion equipment is restricted to 15-tons total weight, so is the reactor skid.

*This article is based on three papers presented at the American Nuclear Society-Franklin Institute Symposium, February 10-11, 1960. TEMPERATURE OPTIMIZATION OF THE GCRE-I FUEL ELEMENT by W. J. Houghton, P. M. Williams, and S. T. Perkins. POWER CONVERSION EQUIPMENT FOR THE ML-1 NUCLEAR POWER PLANT by C. M. Rice, and R. K. Swain. THE ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM by G. A. Newby. All authors with Aerojet-General Nucleonics, San Ramon, California.

From a logistics standpoint, the power plant must operate with no more than periodic field maintenance for 10,000 hours between major overhauls. Total operational lifetime of the equipment is expected to be 50,000-hr.

Power Conversion System

This is a closed-cycle system in which nitrogen (the working fluid) at a base pressure of 115-psia flows into the compressor, where the pressure is raised to 315-psia. The nitrogen flows through the recuperator's cold side to reclaim turbine exhaust heat; then, at 800°F, it flows to the reactor, where it is heated to 1200°F. From there, the working fluid flows through the turbine and into the recuperator, where exhaust heat is used to heat the compressor discharge. From the recuperator, nitrogen flows through the precooler and back into the compressor.

Speed control is accomplished by bypassing nitrogen around the turbine as necessary, so that a portion of the gas flows directly from compressor discharge to precooler.

Power Conversion Equipment

A prototype of the power conversion system is now being tested at Ft. Belvoir for the US Army Corps of Engineers by Aerojet. Test results are being utilized in design of the following major components.

Generator—This is a brushless, electromagnetic type being designed and built by Aerojet. It is rated 400-kw, 2400/4160-v, 3-phase, at a 0.8PF. It is a 2-pole alternator, operating at 3600-rpm. The unit is 38-in. in diameter and 34-in. long, including starting motor. It weighs 3400-lb.

Considerable manufacturing experience exists with smaller versions of the same type of alternator. Since there are no brushes, slip rings, magnetic rotors, of rotating diodes, a trouble-free lifetime of 50,000-hr is anticipated.

Turbine-Compressor Set—This is the most important component in the power conversion system and represents the most advanced design concept. At the present time, two different types of turbine-compressor sets are being developed. One is an axial-flow concept, being developed by Clark Bros. Co.; the second is the centrifugal type, being developed by Stratos Division, Fairchild Engine and Airplane Corp.

The two assemblies are being designed to be inter-

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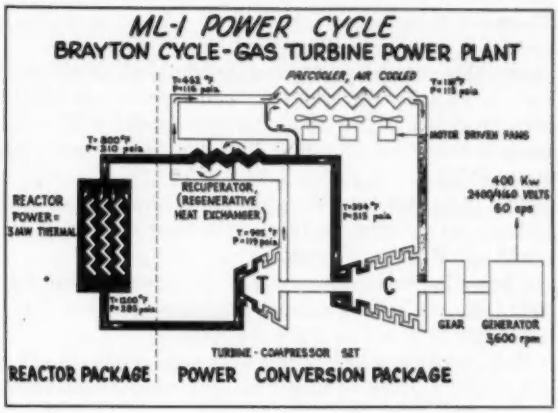
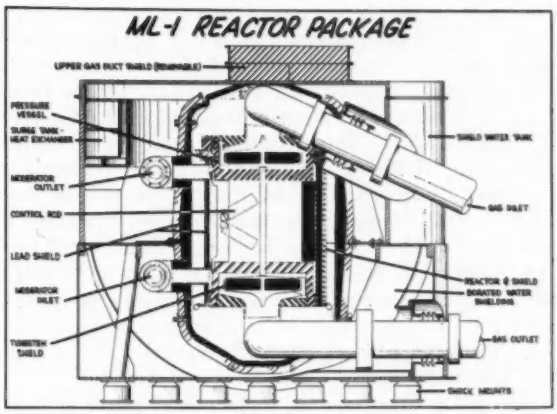
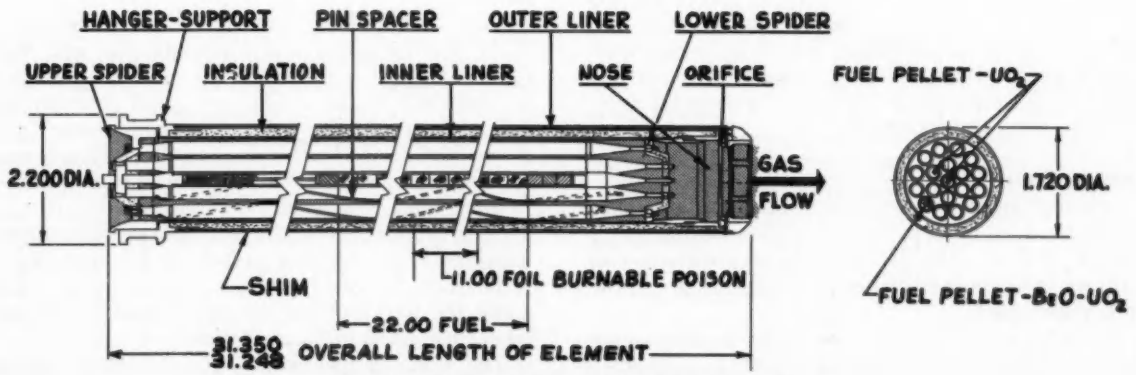






ML-1 First core fuel element. Nitrogen gas to the turbine passes through this tube where it is heated by the fuel in the inner pins, note direction of gas flow.

Gas Turbine—Nuclear . . .

(Continued from page 29)

changeable on the power conversion skid. Both units have essentially the same performance characteristics with expectation that the axial-flow model will be the more efficient of the two; the centrifugal unit, the more stable.

The axial flow machine has an 11-stage compressor and a 2-stage, reaction type, axial-flow turbine. Rotational speed is 22,000-rpm.

The radial-flow machine has a 2-stage compressor and a 2-stage, reaction-type, axial-flow turbine. Rotational speed is 18,000 rpm.

Both units are similar in size and weight. Each is 46-in. long (including gear box) and 24-in. in diameter. Each weighs 1600-lb.

Although the machines are basically different, their construction details are very similar. In both cases, first critical speed is approximately 125% of rated speed. Both types utilize similar bearing and seal arrangements.

The radial bearings are plain grooved journal types, fabricated from babbit-bronze material and run against a hardened shaft. Thrust bearings are pivoted slipper-type, also fabricated from babbit-bronze material.

"Bleed" nitrogen is obtained from the fourth stage of the axial-flow compressor and from the first stage of the centrifugal compressor to ensure that correct pressure drop is maintained across the seal labyrinth during all possible pressure fluctuation. During the startup transient period, while the unit is generating its own bleed pressure, a small external compressor will provide the barrier nitrogen.

Precooler—This consists of two units integrated into one package. They are: (1) the nitrogen precooler used to reject waste heat to the atmosphere; and (2) the water moderator cooler. The package is mounted above the other power conversion equipment. The complete unit, including fans and their motors, weighs 5800-lb. Its total length is 162-in. of which 132-in. are occupied by the nitrogen cooler, the remaining 30-in. occupied by the moderator cooler. The unit is 113-in. wide. Overall core thickness is 32-in. The core itself is 15-in. thick; the fan plenums are 17-in. thick.

Recuperator—This unit returns turbine exhaust heat to the compressor discharge and thus improves system efficiency. The unit is a shell-and-tube exchanger. Low-pressure gas from the turbine exhaust makes one cross-flow pass over the tubes. High-pressure gas from the compressor discharge makes four passes through the exchanger inside the tubes. These are 3360 tubes which, in this four-pass arrangement, are equivalent to 840 parallel tubes.

The unit is fabricated entirely of stainless steel and is 79-in. long, and 47-in. in diameter; weighs 3800-lb. Its effectiveness is 81%.

Reactor—The reactor core resembles a tube-and-shell heat exchanger, in which the shell side is filled with unpressurized water. Gas inlet and outlet ducts contain two 90-deg elbows to reduce neutron streaming during reactor operation. The shielding water tank is kept full of heavily-borated water during operation.

The tank is thermally insulated from the atmosphere. Moderator water enters and leaves the core through radial pipes in the circumferential shielding. Energy transfer from coolant gas to moderating water is limited by a layer of insulation surrounding each fuel element. Tungsten discs inside the plenums provide gamma-ray shielding. The core is encased in lead and tungsten shielding which also acts as a fast neutron reflector.

Testing

The reactor is scheduled for test next year at the National Reactor Testing Station in Idaho. Proof of the adequacy of the ML-1 system and its components will be demonstrated in an extensive test program and, finally, during actual operation of the power plant.

Natural Gas-Burning Turbines . . .

(Continued from page 19)

Station services are supplied by a 5000-kva 13,800/2300-v transformer with two diesel generating sets as standby. The diesel sets, rated 350 and 1500 kw, enable the plant to be started during a system shutdown. To maintain lighting and station services in the plant, shutdown power can be fed to the 460-v bus from a nearby 6900-v distribution line.

Remote Control . . .

Signals from the Vancouver head office are transmitted by microwave radio to Ingledow Substation, a distance of three miles. Here, signals are converted and continue by a single side-band power line carrier to the Port Mann plant.

To start a unit by remote control, the turbine switch is simply turned to the "run" position. This causes a light to flash, indicating that the information has been received.

The impulse received at the station initiates (in correct sequence) all operations for starting the plant. Fuel and cooling water valves are opened, auxiliary motors started, and starting motors for low-pressure and high-pressure shafts bring their stages to firing speed (approximately 30% synchronous speed) within about four minutes.

Once combustion chambers are fired, the gas turbines develop power and accelerate the sets. When operating speed is reached, each unit is automatically synchronized to the system and speed governor takes over. After execution of the command, another signal is sent back to the head office and the light of a mimic system diagram stops flashing, indicating required action has been completed.

Once the plant is on the line, load or voltage can be increased or decreased by pressing appropriate buttons.

To start the station under emergency conditions, (with the bus dead and no power available for auxiliaries) the diesel units are started first.

The plant is completely self-protecting. Although alarm indications are sent to the head office and are shown by control panel warning lamps, alarms are backed up by protective devices in the plant itself.

Russian Report . . .

(Continued from page 15)

as to specific installations. Operation of installed plants has probably been limited up to now.

Four 4750-gross tonnage bulk carriers are being built with free-piston gas turbine propulsion plants. Four GS 34 gasifiers, built by SIGMA, deliver gas at 3.1 atmospheres and 842°F, to a gas turbine of Alsthom manufacture. The turbine is geared from 5500 down to 115 rpm and delivers 4000 shp to the propeller.

Plans have been reported for a gas turbine driven tanker. The ship is scheduled for the Admiralty Shipyard in Leningrad.

The ship will have the following characteristics:

Length between perpendiculars, ft	550
Beam, greatest, ft	75
Draft, ft	30
Displacement, ton	26,790
Speed, planned, knots	17.1
Horsepower, maximum	13,000
Cruising, radius, miles	10,000

The propulsion plant consists of an open-cycle gas turbine, exhausting into a waste heat boiler, that is geared to a controllable-pitch propeller. Main turbine control stations are located on the bridge and also in the engine compartment. By using gas turbine propulsion, a saving of 20-25% in operating personnel is anticipated.

Hydrofoil boats have been built and tested in various sizes by Russia. Passenger-carrying boats are under design that will have capacities for some 300 passengers. Gas turbines will be used for propulsion of many new hydrofoil craft where high specific power is essential.

Conclusion

In closing, we find the only Russian mass-produced gas turbine are their aircraft units. Even their rocket turbines, so widely publicized, must be made a few at a time, same as the rockets. Practically all other fields have been covered by building various sizes of prototypes. There is one thing certain and that is the Russians are placing themselves in an excellent position by actually constructing these prototypes. They will definitely be in the gas turbine business in the years to come.

Table 1
Compressor and Turbine Data for 300,000-kw Gas Turbine Plant

Rotor	Stage	Blade Size, mm		
		Height	Chord	Mean Diam.
1st Compr.	First	775	240	2325
5th Compr.	First	88	99	1044
5th Compr.	Last	60	99	1016
4th Turbine	Last	757	141	3030
1st Turbine	First	137	121	750

Sh-hhh! Silencers At Work . . .

(Continued from page 27)

turbine packaged-power plant could be constructed relatively quickly, with a minimum amount of piping, space, and similar requirements. Second, because the company owned its own gas transmission lines, the gas-oil dual-fuel aspects of gas turbines were desirable. Third, the comparatively little cooling water requirements of the units were an important factor. And, fourth, the company figured it would save engineering costs and construction time because the gas turbines would not have to be matched up with existing equipment.

Montana-Dakota installed two 4000-kw General Electric simple-cycle dual-fuel gas turbine drive generators with all accessory equipment. Although rated 3900-kw under station conditions (4000-kw standard), the units provided a capacity of 5000-kw, operating with either oil or gas.

Some Plant Details

Ebasco Service, Inc., of New York, who also acted as purchasing agents, designed and constructed the plant. Through courtesy of Ebasco Services your Consulting Editor visited this plant during the last stages of construction. One turbine was all ready to put on the line, the second was getting ready, and the silencers were being installed—at 40°F below zero!

Because pressure in the gas transmission lines sometimes fluctuated below full requirements for the units, two Gardner-Denver motor-driven booster compressors with adequate aftercoolers, regulators, and receivers were installed below the main air-intake filters.

Each turbine had an individual exhaust system which included a combination muffler and stack.

Silencing Effective

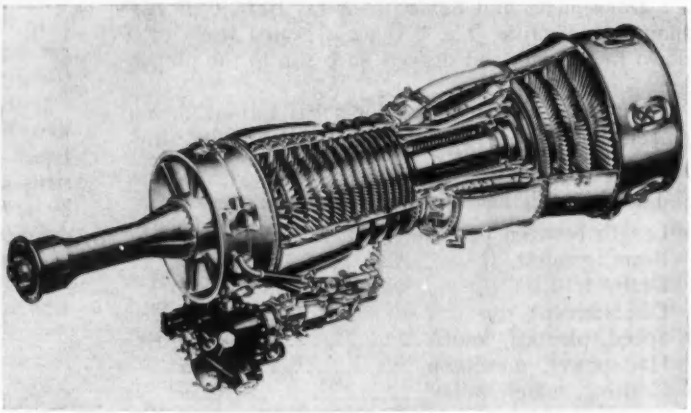
Normal noise level in the area was from 62 to 71-decibels; normal vehicular traffic in the area raised the level to 79 to 90-decibels. With the Burgess-Manning silencers installed and turbines in operation, readings taken downwind from the plant indicated a slight increase over normal noise level. When the wind blew toward the plant, operation of noise of the turbines was not even perceptible.

Sound surveys were also taken inside the building and the noise ranged from a maximum of 98-decibels when readings were taken at a point between the two turbines. (Observers said that, in fact, noise level compared favorably to the company's steam turbine plant.)

Representatives from jet aircraft engine companies even visited the plant to observe the silencer installation in the course of their studies to reduce noise level of their test cell operations.

Long recognized as one of the leading specialists in sound engineering and noise control, they point out that all sound yields to analysis. It is then a matter of experience and technology to design and build silencing equipment that will reduce the sounds to acceptable levels.

GT PRODUCT NEWS



Take a Peek At GE's T64

First cutaway view of General Electric's T64 aircraft gas turbine was released with announcement that the turboshaft configuration—YT64-2—passed its preliminary flight rating test. Design characteristics of the engine include: 14-stage axial flow compressor (12.6-to-1 pressure-ratio and 24.5 pounds per second airflow); short annular split combustor case with externally mounted nozzles and ignitors; split turbine casing, housing a 2-stage gas-generator turbine and a 2-stage free power turbine with coaxial shaft. 2780 hp was developed on test with a fuel consumption of .490 lb/hp hr.

150

Use your GT Reader Service Card.

Non-Capacitance Liquid Level Indicator

A liquid level indicator that does not depend upon capacitance or capacitors has been developed by the Electronics Department of Hamilton Standard. It can be used to measure lubricants and other liquids on aircraft and industrial engines and on a wide range of processing equipment.

Its main components — an electronic control and a unique sensing element which are combined as a single unit—can be engine-mounted and installed where heat and vibration prevent the use of conventional indicators. Tested on a Pratt & Whitney Aircraft J-75 engine, the new indicator continued to function accurately after more than 200-hr of high-temperature operation.

151

MORE NEW PRODUCTS FOLLOW ►

Good News Regarding Additives

R. S. Norris & Associates, have announced the availability of a liquid, oil-soluble fuel oil additive to inhibit corrosion and deposits caused by vanadium, sodium, and sulfur present in No. 6 fuel oils for gas turbines. Advantages of this additive are:

1—No pre-mixing of dry chemicals is required.

2—Liquid additive may be injected into fuel supply line by means of a small proportioning pump, thereby permitting flexibility of dosage in treatment of fuel oils of varying ash content . . . or may be added directly to fuel in main storage tank or day tank.

3—On a weight ratio of magnesium from the additive, to vanadium and/or sodium in fuel oil, it is a far more effective inhibitor than application of dry chemicals injected as slurries or aqueous solutions.

4—This liquid additive is far less expensive than other oil-soluble compounds such as naphthenates, stearates, etc.

Generally it's assumed that application of magnesium sulfate as an aqueous solution is an expensive fuel treatment, (as is also the case with magnesium oxide when mixed as a slurry). While it is true that cost-per-lb for these dry chemicals is inexpensive, the capital expenditures required for mixing tanks, agitators, circulating pumps, etc., may be considerable. Also mixing these chemicals must be considered. Certainly for marine and portable installations, where space limitations are a factor, the premixed additive is more desirable.

152

Tiny Fuel Control Pump

A turbine fuel control weighing only 1.875-lb, complete with shutoff solenoid, has been added to the extensive family of similar controls built by Garrett Corporation's AiResearch Manufacturing division, Phoenix, Arizona. Current applications for the tiny control include use on AiResearch small gas turbines in the 30 to 50-hp range.

153

Jet Engine Test Stands

Delivery of the first jet engine fuel control test stands designed and manufactured by Hamilton Standard's Ground Support Equipment department has been made to Naval Air Station at North Island, California. Stand will test and calibrate overhauled fuel controls of the Allison T-56 turboprop and General Electric T-58 turboshaft engines used on Navy aircraft.

154

Mobile Allison Test Stands

Air transportable mobile test stands which will enable the Navy to check the operation of Allison Prop-jet powerplants "on location" at far-flung shore installations are being fabricated at the Allison Flight Test Research Facility. Handles prop-jets up to 4500 hp . . . weighs only 15,000 lb! Deliveries start next January.

155

Delavan specialists solve

JET-AGE FUEL INJECTION PROBLEMS

■ Exacting fuel injection performance is especially critical in aircraft, missiles, helicopters and APU air-ground installations. Delavan specialists have developed injectors that perform within the most demanding tolerances in high and low temperature environments as well as handle corrosive and abrasive fuels.

■ When you are considering a new or difficult fuel injection application be sure to consult with us. A Delavan designed and manufactured injector may well reduce costs, save you valuable time or improve the performance of your equipment.

■ Delavan can bring a fund of developmental experience and manufacturing know-how to your fuel injection problems . . . know-how that is unparalleled in the industry. Delavan is the world's largest manufacturer devoted to the design and manufacture of fuel injectors and spray nozzles.

■ *If an exacting fuel injector for gas turbines is needed . . . so is Delavan. For information write:*

DELAVAN Manufacturing Company
WEST DES MOINES • IOWA

For more information write in No. 137

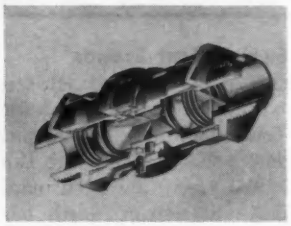
Details on Kelsey-Hayes Udiment 200 Alloy

Udiment 200 is a vacuum-induction-melted, precipitation hardened alloy. It's designed for applications requiring relatively high stresses at intermediate temperatures of 1000°F to 1500°F. Udiment 200 is readily adapted to aircraft and industrial gas turbines . . . components . . . turbine rotors . . . compressor discs, as well as structural engine components.

Udiment 200 is machined using highspeed cobalt cutting tools with slow speeds and heavy feeds. It can be welded by standard Inert Gas Tungsten Arc processes using Udiment 300 filler wire. (All welds should be aged for optimum performance.)

Udiment 200 sheet is easily formed in the annealed condition and has a .2% Y.S. of approximately 45,000 psi and an ultimate tensile of 100,000 psi and Ultimate Tensile Strength of 160,000 psi is obtained.

156



New Quick-Connect Fluid Couplings

Jack & Heintz, Inc. has started volume production of new quick-connect couplings designs. Complete standard line of aviation couplings includes Self-Sealing and Open-Type Quick-Connect Couplings for AN flared tube, pipe, hose and special connections. Designs are now being completed for a complete line of No-Air Inclusion and Air Start Quick-Connect Couplings.

J&H's ROTO LOCK couplings will be available in production sizes from ¼-in. through 3-in., with no limit in size for special designs. Range of materials includes aluminum, stainless steel, carbon steel and plastic. Couplings can be used for the quick connection of hoses, pipes or tubing in systems handling fluids ranging from air through exotic fuels.

157

New Bristol Siddeley Ducted-Fan Engine

Bristol Siddeley is actively in progress on a ducted-fan engine of 7350 lb thrust and 1485 lb dry weight. BS 75 has been specified as the powerplant for British Aircraft Corporation's 107 and the Avro 771 twin-jet short haul airliners. Fan is mounted at the front (in the form of an enlarged low-pressure compressor, driven by an independent turbine).

Significant feature of all Bristol Siddeley ducted fans is the use of a high-by-pass or flow ratio. This means more air goes through fan duct than through combustion chambers, resulting in a much lower fuel consumption and noise level than the pure jet.

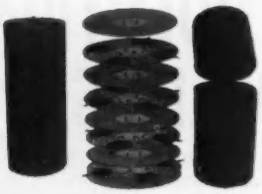
158

HILCO® FULL FLOW FILTERS

FOR MAXIMUM GAS TURBINE BEARING PROTECTION
AVAILABLE FOR LUBRICATING AND FUEL OIL . . .

with these features:

- High flow rates
- Low pressure drop
- Choice of filter cartridges
- Large dirt storage area
- All steel welded construction
- In-out pressure gauges
- Quick action cover lifter
- 100 psi standard design pressure
  Higher pressures upon specification
- Swing bolt cover construction



HILCO FILTER CARTRIDGE TYPE FW-718 COMBINATION EXTENDED SURFACE AND DEPTH MICRO FILTRATION

HILCO FILTER CARTRIDGE TYPE PL-718 EXTENDED SURFACE FOR EXTREMELY HIGH FLOW RATES

"F" Series HILCO HYFLOW OIL FILTER

HILCO FULL FLOW FILTERS Available in capacities up to 2000 GPM and Micro Filtration at that . . . Removing Particles 5 Microns and Smaller

• Write to the PIONEERS of Micro Full-Flow FILTRATION

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210 WEST FOURTH STREET
ELMIRA, NEW YORK

For more information write in No. 138

Los Angeles Uses Gas Turbines

World's first turbine-powered helicopter for use in scheduled airline service was turned over to Los Angeles Airways by Sikorsky Aircraft at the Sikorsky plant.

The S-62—powered by a single GE T-58 gas turbine engine—carries 10 passengers and a crew of two at a cruising speed of about 100 mph. Its amphibious design (featuring a flying boat hull) enables it to operate from land, water, ice, snow, swamp—just about any surface! The aircraft has an airline interior designed by Raymond Loewy. Price of the helicopter is $300-thousand.

Clarence N. Belinn, president of Los Angeles Airways, said that acquisition of the S-62 represents "Phase One" in LAA's plan to replace its present piston-engine fleet with turbine-powered "copterliners". Next step, he indicated, will be to place in operation three 28-passenger, twin-turbine Sikorsky S-61S next year, with two more to follow in 1962.

159

Use your GT Reader Service Card.

Alloy News From Kelsey-Hayes

Composition of alloy V-57 was modified following a statistical experimental design. Results of this investigation indicated that a modification of major alloying constituents (and an adjustment of some minor elements) are beneficial to the mechanical properties of this alloy. Specimens showed a UTS of 180,000 psi under specified conditions after treatment to 1800°F and oil quenched.

Recent experiments on cold reduction of Udiment 41 have illustrated that hardness up to 60 Rc can be developed in thin sections. Data obtained can be safely applied to other superalloys such as Udiment 500, Udiment 700 and Waspaloy.

Use your Reader Service Card for further details.

160

Bristol Siddeley Engines To Power German PT Boats

Vosper Ltd., of Portsmouth have announced the signing of a contract with the Federal German Ministry of Defense for two motor torpedo boats for the Federal German Navy, capable of a speed of over 50 knots.

One of these will be a 3-engined boat similar to the Royal Navy's Brave Class but with slightly more powerful Proteus engines. Second boat will be somewhat smaller and will have two Proteus engines. In both cases Allen reverse reduction gears will be used and the auxiliary generators will be driven by Rover gas turbines.

161

One Year Between Overhauls!

General Electric's CT5B-100-1 turbine engine has become the first US helicopter powerplant (either piston or gas turbine) to receive 1000-hr FAA approval for time between overhauls (TBO), it was revealed by R. T. Holland, manager of T58 commercial sales. New rating applies specifically to Sikorsky's S-62. This 1000 hr represents more than a year of normal operations for a helicopter.

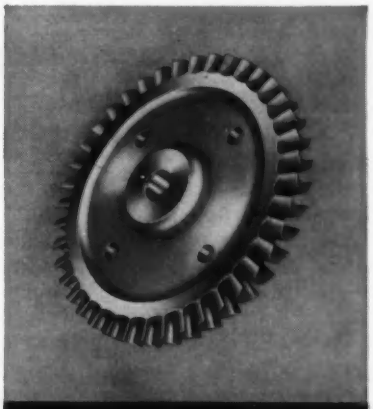
162

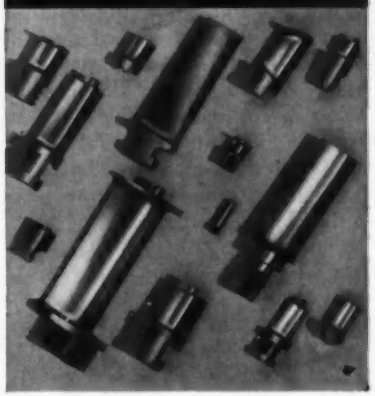
New Alloy For Forging Rotors

Steel Improvement & Forge Company is using forged rotors of Allegheny Ludlum A-286. This new alloy allows them to operate rotors at increased temperatures where top engine efficiencies are possible. This new metal, developed by Alleghany Ludlum, is an iron-base alloy which is vacuum-melted by the consumable electrode process to insure cleanliness and strength. Also, A-286 is additionally strengthened by an aging treatment known as precipitation hardening. A-286 develops its best properties in temperature range of 1200° F. S I & F finds that use of A-286 has eliminated the tendency to crack under stress of forging and forming that previously used air-melted alloys had.

163

(Continued on page 40)





The Schellens-True organization is devoted exclusively to the manufacture of turbine blades, wheels, vanes and nozzles of all types, machined from a wide variety of alloys and materials. We have developed entirely special automatic blade and wheel machining equipment available nowhere else. Creative engineering, precision manufacturing and rigid quality control assure a reliable product at a minimum cost.

May we quote on your requirements?

SCHELLENS-TRUE CORP.
Ivoryton Connecticut

For more information write in No. 139

GT PRODUCT TECHNICAL FILE

Filters Inc. Reports

Here's a 4-color brochure designed to be a part of your files! Filters Inc. —specialists in design and manufacture of liquid filters for turbine fuels —describe a remarkably efficient element now being widely accepted and recognized for high-performance military and industrial applications.

Facilities for testing and research are also detailed. Folder details rigid testing methods used . . . and the results obtained. Use your Reader's Service Card to obtain your copy of this helpful, informative brochure.

164

Hydrofoil Book Available

A "Study of Hydrofoil Seacraft" made by the Grumman Aircraft Engineering Corp., has been published by the Maritime Administration, it was announced by Vice Admiral Ralph E. Wilson, Maritime Administrator, US Department of Commerce. While a summary of the study was published in 1959, interest has been indicated in having the complete report made available.

"Study of Hydrofoil Seacraft," PB 161759, is available through the Office of Technical Services, US Department of Commerce, Washington 25, D. C. for $6.00 per copy.

165

New Clark Brochure Discusses Gas Turbine Pros & Cons

Economics of gas turbine power generation for US Defense sites and for commercial applications are discussed in new Bulletin 202, just issued by Clark Bros., Co., one of the Dresser Industries. Comparative analysis of gas turbine, steam, and diesel generating plants is made. In the conclusion this statement is made, "It is felt from the foregoing that it becomes obvious that the gas turbine should never be discounted in any installation requiring power."

166

New Brochure From Aerotest

Unique Advanced Propulsion and Environmental Test and Research facilities are described in Aerotest Laboratories new 26-page illustrated brochure. Complete space orientated laboratory facilities, for functional and environmental testing of components and systems — from sub-miniature electronic to gas turbine engines—are summarized in detail.

167

Use your GT Reader Service Card.

Breeze Corp.'s Catalog Lists Starters, Generators

A catalog file covering all standard and custom starters and starter generators is now available from Breeze Corporation. File includes full line of 75-amp, 100, 200 and 300-amp starter generators as well as the direct cranking electric starters now produced by Breeze. The equipment is finding increasing use on gas turbines. Specifications and performance curves are shown in the catalog.

168

"Jet Power Coming Down To Earth."

This is the title of a new brochure published by Pratt & Whitney Aircraft. It describes six gas producers ranging from 350 to 15,000 hp with an air flow from 5 to 218 lbs/sec. "Perhaps you can envision one of these powerplants introducing welcome economies to your own operation."

169

New GE CJ610

Bulletin GED-4208A announces General Electric's new CJ610 Turbo-jet, 2700-lb thrust jet engine for corporate aircraft in the 10,000 to 16,000 lb class. GE's bulletin also points out the feasibility of using the CJ610's 4000-lb-thrust companion engine, the CF700, to meet airframe growth requirements.

170

Bulletin Describes Benefits of Chromallizing

Effects of chromallizing superalloy gas turbine vanes are detailed in a 4-page, illustrated technical article from Chromalloy Corporation. Chromallizing is a metal-diffusion process which protects the vanes against damage from high operating temperatures. Increasing the temperature means higher shaft horsepower without major engine modifications

171

New Clark Bros. Brochure

New Bulletin 198 describes Clark Bros. recently introduced 9000-hp single-shaft gas turbine. Primary design considerations of simplicity, low first cost, easy access to all areas and high reliability are first discussed—followed by a detailed description of major components with pictures, illustrations and diagrams.

172

Dampney "Coatings in Color" Protect Metals Up To 1400°F!

This handsome bulletin describes the Dampney line of heat resistant coatings for maintenance painting and industrial and architectural finishing.

The silicone-ceramic heat-resistant coatings cover all temperature situations, up to 1400°F. Selection is determined by actual skin temperature of metal, normal and peak, and rate of heat rise; corrosive environment and atmospheric exposure. Protect metal . . . prevents severe corrosive action. Comes in aluminum or color of your choice.

173

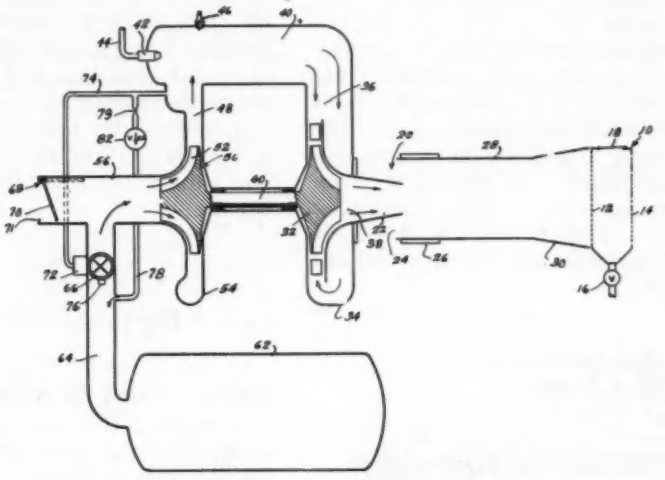
Gits Hi-Temp Ring Seal

Four page brochure covering "the first all-metal linear seal commercially available" has been published by Gits. Has a table as well as other information giving detailed data.

174

GT PATENTS

By J. W. Sawyer



GAS TURBINE ENGINE ACTUATED STARTER AND DRYER (2,941,970) 8 CLAIMS William A. Compton, Euclid and Harvey A. Cook, Chagrin Falls, Ohio, assignors to Thompson Ramo Wooldridge, Inc., Cleveland, Ohio. A gas turbine and compressor are utilized for drying materials such as hay and grain. The unit is a self-operating mobile heat source. It provides a supply of hot gas which is forced through the material to be dried in container (10). Gas at necessary velocity and temperature is supplied through the aspirator (20). The quantity of air entering opening (24) can be controlled by movable annular part (26).

MINIATURE GAS TURBINE (2,945,349) 6 CLAIMS Emil Ritzi, Manhattan Beach, California, assignor to Lear, Incorporated. An air-breathing gas turbine to produce shaft-power in order of 10 hp with efficiency comparable to that of larger machines.

TURBO COMPRESSOR (2,938,663) 6 CLAIMS Bruno Eckert, Stuttgart-Bad Cannstatt, and Heinrich Kuhl, Stuttgart, Germany, assignors to Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany. An axial flow compressor which controls boundary layer at the blade in such a way as to accelerate layer and prevent flow separation.

AFTERBURNER FUEL SCHEDULING CONTROL WITH ENRICHMENT AT LOW COMPRESSOR DISCHARGER PRESSURE (2,934,441) 17 CLAIMS Howard H. Dietrich, John D. Hiller, Robert Lay, Mark R. Rowe, and Harry C. Zeisloft, Rochester, N. Y., assignors to General Motors Corporation, Detroit, Michigan.

FUEL CONTROL VALVE MECHANISM FOR USE WITH A GAS TURBINE POWER PLANT OR THE LIKE. (2,941,357) 5 CLAIMS David W. Barton, Birmingham, Mich., assignor to Chrysler Corporation, Highland Park, Mich.

ROTARY REGENERATIVE HEAT EXCHANGER (2,946,573) 9 CLAIMS Teodor Immanuel and Tor Axel Odman, Stockholm, Sweden, assignors to Svenska Rotor Maskiner Aktiebolag, Nacka, Sweden. This exchanger utilizes wire mesh for the matrix.

SEALING MEANS FOR ROTARY REGENERATIVE HEAT EXCHANGER (2,942,857) 3 CLAIMS Charles A. Lyle and Robert H. Muller, Wellsville, N. Y., assignors to The Air Preheater Corporation, New York, N. Y. Means for substantially reducing the amount of high pressure fluid lost due to entrainment in the rotor while simultaneously reducing the direct leakage between the high and low pressure fluid streams.

IGNITER CHAMBER FOR A GAS TURBINE ENGINE (2,941,364) 5 CLAIMS Morris A. Stokes, Coventry, England, assignor to Armstrong Siddeley Motors Limited, Coventry, England.

VARIABLE PRESSURE WAVE ABSORPTION FOR COMBUSTION CHAMBERS (2,941,356) 7 CLAIMS Arthur W. Blackman, Newington, Conn., assignor to United Aircraft Corporation, East Hartford, Conn. High output combustion chamber equipped with absorption liners to control high frequency noise.

ENGINE ACCELERATION FUEL CONTROL RESPONSIVE TO SPEED SCHEDULED COMPRESSOR PRESSURE RATIO (2,943,447) 23 CLAIMS David Omri Davies, Derby, England, assignor to Rolls-Royce Limited, Derby, England.

ELASTIC FLUID MECHANISM (2,943,839) 20 CLAIMS Rudolph Birman, Newton, Pa., assignor to De Laval Steam Turbine Company, Trenton, N. J. Improved designs of impellers, diffusers and turbines.

BLADED ROTOR CONSTRUCTION FOR FLUID MACHINES (2,945,671) 8 CLAIMS James Alexander Petrie, Littleover, Derby, England, assignor to Rolls-Royce Limited, Derby, England. Blade design is such that fluid passes through internal blade channels for cooling or heating.

VARIABLE JET NOZZLE CONTROL WITH AUXILIARY CONTROL OF GUIDE VANES AND COMPRESSOR BLEED (2,941,354) 18 CLAIMS Albert J. Sobey, Jr., Indianapolis, Ind., assignor to General Motors Corporation, Detroit, Mich.

GAS AND STEAM CYCLE POWER PLANT HAVING TWIN SUPERCHARGED VAPOR GENERATORS (2,946,187) 8 CLAIMS Robert J. Zoschak, Rutherford, and Kelvin J. Ray, Ramsey, N. J., assignors to Foster Wheeler Corporation, New York, N. Y. Gas and steam cycle power plant with twin supercharged vapor generators with means for controlling operation to achieve high efficiency and flexibility over a wide load range.

SIGNAL MODIFIER FOR EXHAUST NOOZZLE CONTROL (2,941,353) 5 CLAIMS Robert N. Abild, New Britain, Conn., assignor to United Aircraft Corporation, East Hartford, Conn.

FUEL CONTROL (2,945,347) 11 CLAIMS Rowan Herbert Colley, Sunnyhill Derby, England, assignor to Rolls-Royce Limited, Derby, England.

(*Continued on page 41*)

STALKER
ORTHOBRAZED
SHEET METAL
FABRICATIONS

Photo courtesy of Continental Aviation and Engineering Corp.

COMBINE LOWER COST, LIGHTER WEIGHT, GREATER STRENGTH

Stalker welcomes intricate, precision product manufacturing assignments involving forming and high-temperature brazing of stainless steel or super alloy sheet metal fabrications. Facilities include engineering, developing and production of strong, weight saving assemblies. Stalker also has facilities for heat treating, annealing and stress relieving, and U.S.A.F. approved quality control. Prototype and/or production orders. Call or write for specific information.

*Up to 48" in dia.

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Essexville, Michigan
Phone: Bay City — TWinbrook 3-7562

For more information write in No. 140

PRODUCT NEWS . . .

(Continued from page 35)

New Multicontoured Heat Exchangers

Multicontoured heat exchangers represent a new concept in heat transfer design, produced for the first time by The Garrett Corporation's AiResearch Manufacturing Company of Los Angeles. They will be installed on opposite sides of the Boeing 707's turbofan engines approximately 180 deg apart. One unit cools oil for the constant-speed drive oil circuit, and the other cools turbocompressor lubrication oil circuit.

175

AiResearch Units Travel Abroad

AiResearch small gas turbine models GTCP85 for all ground power needs have been shipped to France and Germany for an installation check on two new aircraft now in the mockup stage.

One of the turbines goes to Bremen, West Germany, for installation on the joint German-French C-160 "Transall", a turboprop cargo transport built by Weser Flugzeubau, and Nord. The other, to Villacoublay, France for use on Breguet's 1150 "Atlantique", a NATO turboprop patrol craft.

176

Electron Beam Welding Of Molybdenum-Tungsten

USAF has awarded a contract to Hamilton Standard, a division of United Aircraft Corporation, to study welding of molybdenum and tungsten by electron beams. Hamilton Standard holds North American technical and manufacturing rights to electron beam welding and cutting equipment developed by the Carl Zeiss Foundation of West Germany. In the Hamilton-Zeiss machine, the electron welding beam can be focused on a spot less than 0.001 inches in diameter. This pinpointing, plus almost instantaneous heating and cooling of the workpiece, (the beam travels within its vacuum at about 90,000 miles per second) confine fusion and heat-affected zones to a very narrow range.

177

General Electric's 720/722 Unit

Bulletin SAE-109A describes General Electric's high performance Model 720/722 industrial and marine gas turbine. Included are performance specifications, dimensions and installation data, fuel specifications, a development history, a summary of reliability testing, exploded and cutaway views of the engine plus a listing of current field installations.

178

Use your GT Reader Service Card.

Purdue's Flying TV Aerial

Airborne AiResearch small gas turbine generator sets (120-kw) will power television for 5-million midwest students this fall. Programs will originate from Purdue University, transmitted from a specially equipped DC-6 orbiting overhead with the turbines aboard. Equipment for the unique program, extending the range of television transmission from about 50 to 200-miles, is designed and built by Westinghouse Air Arm Division. Development is being financed by a Ford Foundation grant.

179

PROFIT THROUGH RESEARCH

Consulting, engineering and fabrication facilities available for adaptation of gas turbines or conventional power sources for industrial application, such as high-pressure, high volume pumps, compressors or electrical generating packages. Experience includes the design and fabrication of high capacity pumping packages—mobile or skid mounted.

For further information, contact:

WESTCO

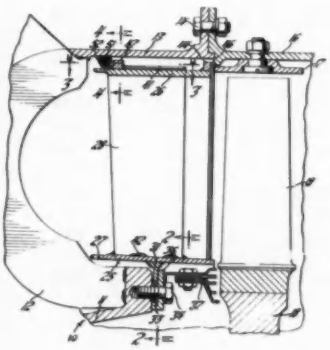
(Western Engineering and Research Co.)
EDison 2-7851, P. O. Box 186, Fort Worth, Texas

POSITION WANTED—Experience in the Design and Testing of small and medium-sized gas turbines offered. Young German graduate with good theoretical background and fluent English would like to work in similar field in the USA. Please contact Box R-11, c/o Gas Turbine, 80 Lincoln Ave., Stamford, Conn.

Patents . . .

(Continued from page 39)

TURBINE NOZZLE (2,942,844) 6 CLAIMS Elroy P. Neate, Indianapolis, Ind., assignor to General Motors Corporation, Detroit, Michigan. This structure is adapted to withstand wide operating ranges of aircraft turbines where high temperatures and quick starts are experienced. Continuous shroud rings and loose connections between vanes and one of the shroud rings are provided. The frame of the engine interconnecting turbine and compressor and supporting the main shaft includes ring



(11) connected by a number of radially extending gusset plates (12) to turbine nozzle casing (13). Gussets (12) are welded to ring (11) and casing (13). Thus (11) and (12) form a support for the casing from the engine frame (10). Turbine case (16) is fixed on the nozzle case (13) by bolts (14). Inner shroud ring (27) is mounted on support ring (11) by a method which provides for relative radial expansion for these parts but prevents any axial or rotational movement of the shroud rings.

ELASTIC FLUID TURBINE AND COMPRESSOR WHEELS (2,941,780) 5 CLAIMS Werner T. von der Nuell, Santa Monica, Richard W. Winslow, Encino, and William D. Whitaker, Manhattan Beach, Calif., assignors to The Garrett Corporation, Los Angeles, Calif. Improved bladed wheel for gas turbines and compressors which is capable of operating at high temperatures and high rotational speeds.

GUIDE VANE ARRAY FOR TURBINES (2,941,781) 6 CLAIMS William B. Boyum, Mt. Vernon, Ohio, assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa. Relates to vibration control for rotary blading of gas turbines, especially concerns apparatus for reducing vibration induced in rotary blading by incoming gas flow through an annular passage to a safe value.

(Continued on page 42)

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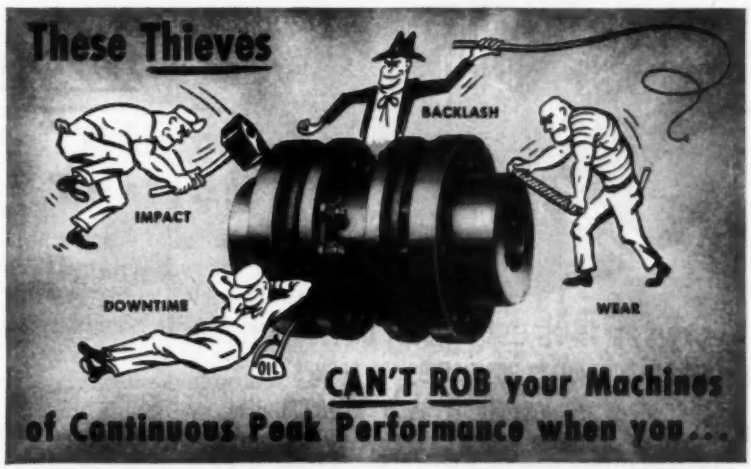

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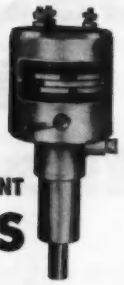

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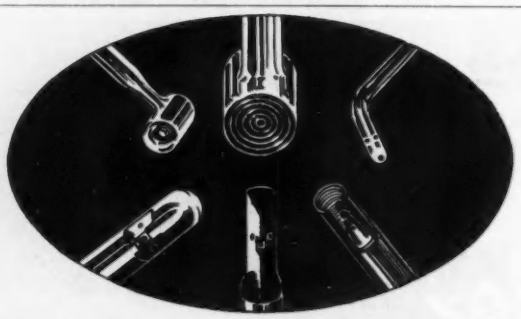

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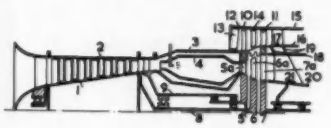

GAS TURBINE PLANT (2,937,495) 7 **CLAIMS** Sidney William Henry Perry, Cove, Farnsbobough, England, assignor to Power Jets Limited, London, England. This power plant is of the ducted fan type providing two separate flow paths in parallel, one through the compressor, combustion system and turbine and the other through a row of fan blades operating in a separate duct and driven from the turbine. Plant consists of: a multi-stage axial flow compressor with a bladed rotor (1) and enclosing bladed stator (2); a combustion system receiving air from the compressor and including an annular aircasing (3) enclosing annular flame tube (4); and an axial flow turbine assembly receiving combustion gases and consisting of three axial rotors (5, 6, 7) with rows of blades (5a, 6a, 7a), rotors (5) and (7) contra-rotate with respect to rotor (6).

MAIN PLANT — consists of two centrifugal compressors, a 12,000 HP synchronous drive motor with a 1.15 service factor for two hours, and a 1,250 HP starting motor. The system is capable of exhausting 85,000 ICFM at a pressure ratio of approximately 3.4. The two compressors can also be used **in series** to supply air at 135 PSIA and 50 pounds per second or, **in parallel** to supply 50 PSIA and 140 pounds per second. The units may also be operated in a push-pull arrangement supplying air at 50 PSIA and simultaneously exhausting at a 3.4 pressure ratio. Exhauster service or pressure is supplied to the test cell building via an arrangement of pipes, and inter-coolers. Simulated flight speeds of Mach 2.5 at altitudes are obtainable with the full 13,250 HP driving motor connected.

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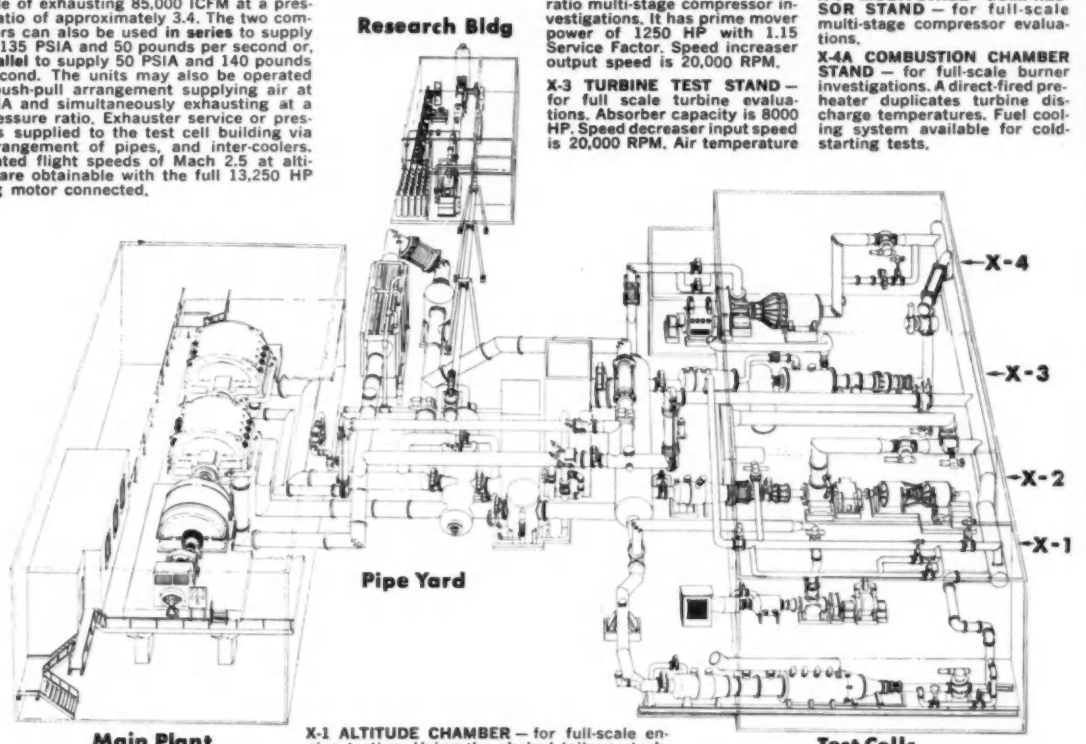
X-4A COMBUSTION CHAMBER STAND — for full-scale burner investigations. A direct-fired preheater duplicates turbine discharge temperatures. Fuel cooling system available for cold-starting tests.



X-1 ALTITUDE CHAMBER — for full-scale engine testing. Using the choked tailcone technique, internal engine performance may be evaluated at simulated altitudes to approximately 70,000 feet. The chamber itself is 8½ feet in diameter and 20 feet long, tested and certified for both pressure and complete vacuum conditions.

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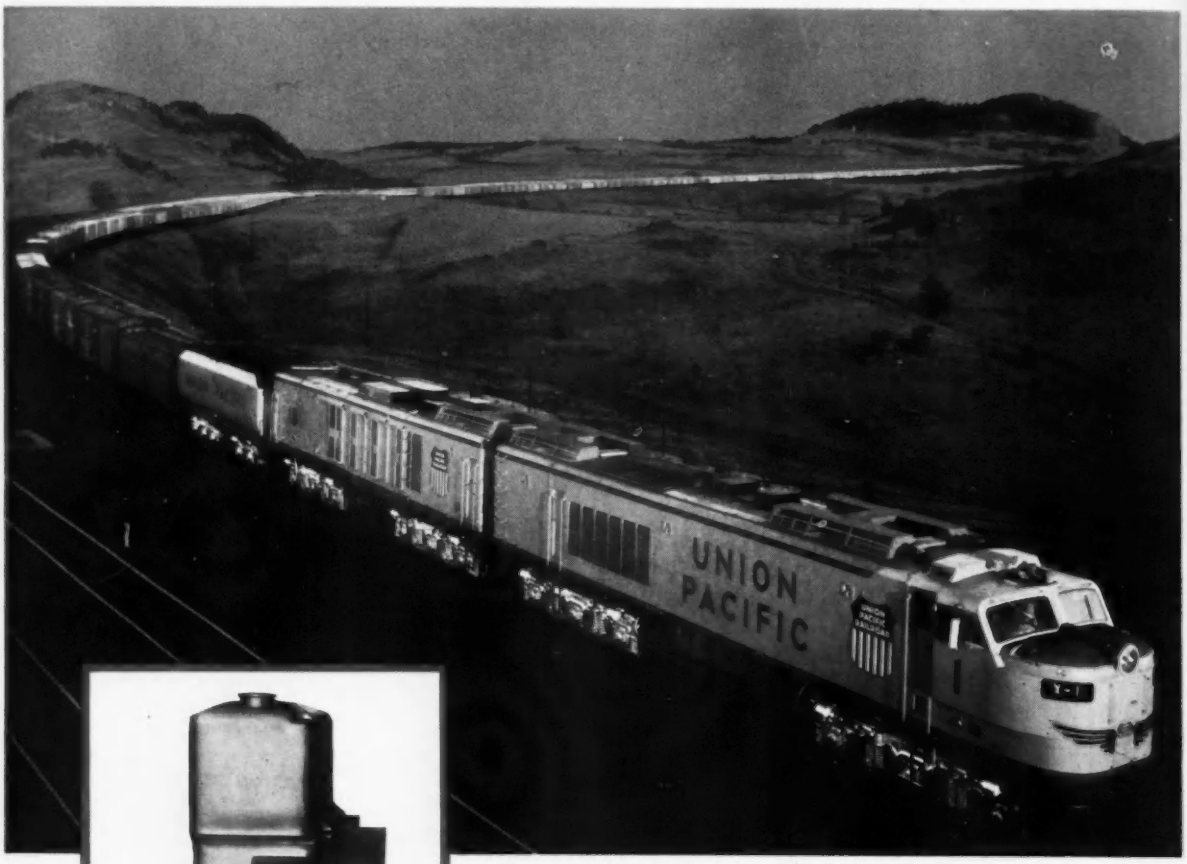

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